AUGUST 1958

Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 50 • NO. 8

Syndetic snow piles up problems as Chanute, Kan., water plant treats and re-treats and re-retreats

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FLUORIDE CHEMICAL AVAILABILITY
Metziger, Gullans, Staff Report

UTILITY SAFETY PROGRAMS
Webb, Hickman, Allen

STANDARD FOR WET-BARREL HYDRANTS
AWWA C503

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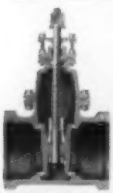

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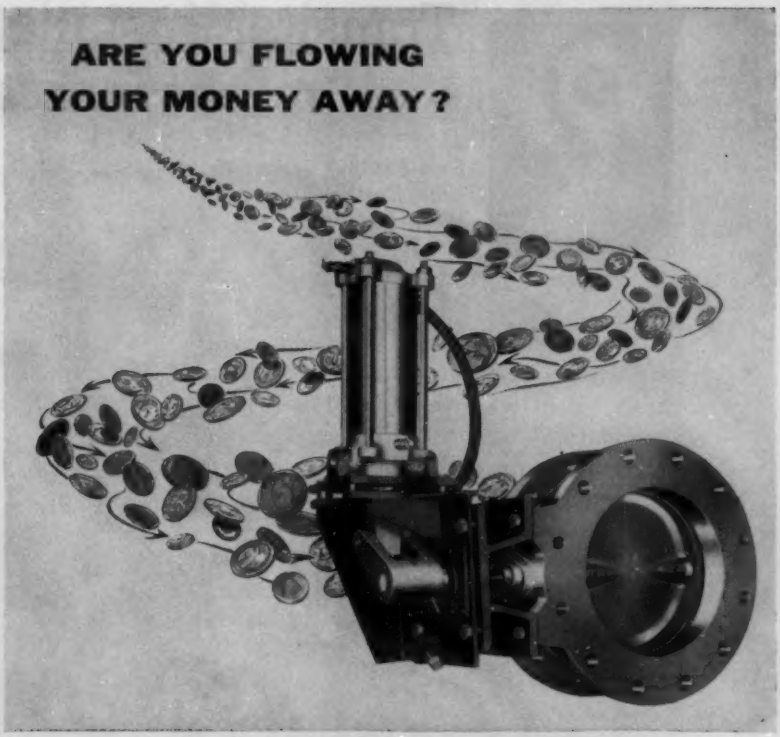

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AWWA SECTIONS

Sep. 8–10—Michigan Section, at Pantlind Hotel, Grand Rapids. Secretary, T. L. Vander Velde, Chief, Section of Water Supply, State Dept. of Health, DeWitt Rd., Lansing 4.

Sep. 10–12—New York Section, at Lake Placid Club, Lake Placid. Secretary, Kimball Blanchard, Rm. 1525, 19 W. 50th St., New York 20, N.Y.

Sep. 15–17—Rocky Mountain Section, at Cosmopolitan Hotel, Denver, Colo. Secretary, V. A. Vaseen, Ripple & Howe, 426 Cooper Bldg., Denver, Colo.

Sep. 17–19—Ohio Section, at Statler Hotel, Cleveland. Secretary, J. H. Bass, Robert F. McGivern & Assocs., 1771—5th Ave., Columbus.

Sep. 17–19—Wisconsin Section, at Hotel Wausau, Wausau. Secretary, Harry Breimeister, Chief Utilities Engr., City Engineer's Office, City Hall, Milwaukee 2.

Sep. 22–24—Kentucky-Tennessee Section, at Peabody Hotel, Memphis, Tenn. Secretary, J. Wiley Finney Jr., Howard K. Bell, Cons. Engrs., 553 S. Limestone St., Lexington, Ky.

Sep. 24–26—North Central Section, at Hotel Duluth, Duluth, Minn. Secretary, L. N. Thompson, Gen. Mgr., Water Dept., St. Paul 2, Minn.

Sep. 28–30—Missouri Section, at Hotel Governor, Jefferson City. Secretary, Warren A. Kramer, State Office Bldg., Jefferson City.

Sep. 28–Oct. 1—Alabama-Mississippi Section, at Buena Vista Hotel, Biloxi, Miss. Secretary, C. M. Mathews, Mgr., Greenwood Utilities, Box 866, Greenwood, Miss.

Oct. 1–3—Canadian Section, Maritime Branch, at Lord Beaverbrook Hotel, Fredericton, N.B. Secretary, J. D. Kline, Asst. Mgr. & Chief Engr., 162 Lady Hammond Rd., Halifax, N.S.

Oct. 15–17—Iowa Section, at Fort Des Moines Hotel, Des Moines. Secretary, J. J. Hail, Supt., Water Dept., City Hall, Dubuque.

Oct. 19–22—Florida Section, at Golden Gate Hotel, North Miami Beach. Secretary, John G. Simmons, Plant Supt., West Palm Beach Water Co., Box 1311, West Palm Beach.

(Continued on page 10)

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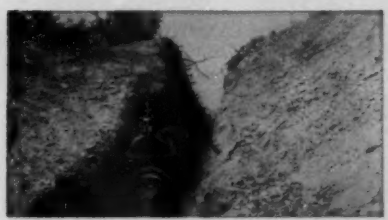

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Coming Meetings

(Continued from page 8)

Oct. 23–24—West Virginia Section, at Daniel Boone Hotel, Charleston. Secretary, Hugh W. Hetzer, Engr., Design & Construction Dept., Union Carbide Chemicals Co., Box 8361, South Charleston 3.

Oct. 23–25—New Jersey Section, at Hotel Madison, Atlantic City. Secretary, A. F. Pleibel, Dist. Sales Mgr., R. D. Wood Co., 683 Prospect St., Maplewood.

Oct. 28–31—California Section, at Ambassador Hotel, Los Angeles. Secretary, Roy E. Dodson Jr., Supt. of Production, Water Dept., Balboa Park, San Diego.

Oct. 29–31—Chesapeake Section, at Hotel Dupont, Wilmington, Del. Secretary, Carl J. Lauter, 6955—33rd St., N.W., Washington 15, D.C.

Nov. 5–7—Virginia Section, at Jefferson Hotel, Richmond. Secretary, J. P. Kavanagh, Dist. Mgr., Wallace & Tiernan Inc., 213 Carlton Terrace Bldg., Roanoke.

Nov. 10–12—North Carolina Section, at O. Henry Hotel, Greensboro. Secretary, D. Y. Brannock, Supt., Water & Sewage Plants, Burlington.

OTHER ORGANIZATIONS

Aug. 27—Water Pollution Abatement Conference, sponsored by Illinois Chamber of Commerce, Sherman Hotel, Chicago, Ill.

Sep. 1–13—2nd International Conference on Peaceful Uses of Atomic Energy, Geneva, Switzerland.

Sep. 7–11—World Power Conference, Canadian Sectional Meeting, Queen Elizabeth Hotel, Montreal, Que. Write: Canadian National Committee of the World Power Conference, Rm. 500, 150 Wellington St., Ottawa 4, Ont.

Sep. 15–20—International Congress on Large Dams, Statler Hotel, New York, N.Y. For information, write: US Committee on Large Dams, c/o Engineers Joint Council, 29 W. 39th St., New York 18, N.Y.

Oct. 5–8—Annual Conference & Products Exhibit, National Institute of Governmental Purchasing, Hotel Statler-Hilton, Boston, Mass. For information, write: Albert H. Hall, Exec. Vice-Pres., NIGP, 1001 Connecticut Ave., N.W., Washington 6, D.C.

Oct. 5–9—Federation of Sewage & Industrial Wastes Assns., Sheraton-Cadillac Hotel, Detroit, Mich.

Oct. 13–17—American Society of Civil Engineers, New York, N.Y.

Oct. 20–24—National Safety Congress & Exposition, National Safety Council, Chicago, Ill.

Oct. 27–31—National Metal Exposition & Congress, Public Auditorium, Cleveland, Ohio.

Nov. 17–19—National Fire Protection Assn., Pittsburgh, Pa.

Nov. 18–20—National Conference on Standards, American Standards Assn., Hotel Roosevelt, New York, N.Y.

Nov. 30–Dec. 5—American Society of Mechanical Engineers, New York, N.Y.

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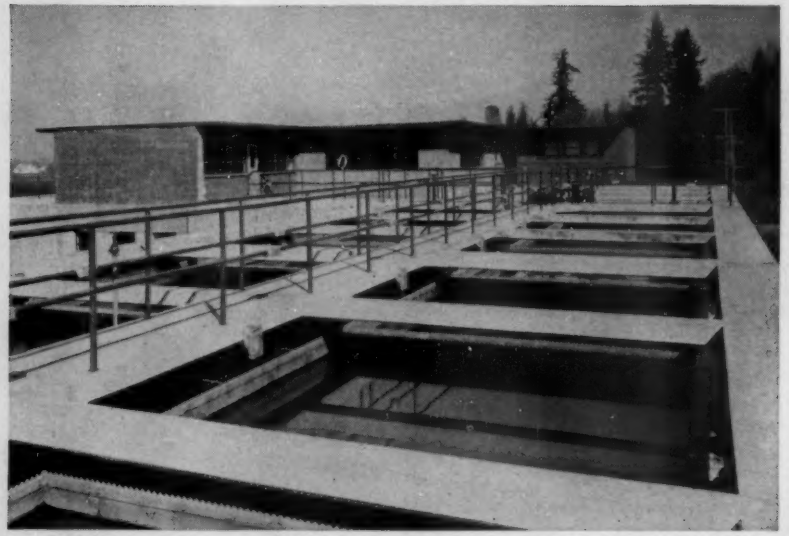
228 North LaSalle Street
Chicago 1, Illinois



REX

4½ m.g.d. Willamette River Water Treatment Plant, Corvallis, Oregon. Illustration of Rex Floctrol and Rex Verti-Flo with modern administration building in background.
City Water Superintendent: Doug Taylor

Corvallis, Oregon Tames Turbidity at Low Cost

Seven years of excellent performance in Corvallis, Oregon, have given added proof of the efficiency and economy of Rex Floctrol and Verti-Flo Clarifiers.

The main problem facing the designers of the new Corvallis plant on the Willamette River was removal of turbidity. Due to seasonal flows, river turbidity varies from 5 to 300 p.p.m., with temperature ranges from 32° to 75° F.

In order to solve this problem, the consulting engineers selected a treatment system incorporating the efficiencies and economies of Rex Floctrol and Rex Verti-Flo Clarifiers.

The results: for over seven years, the effluent from the Verti-Flo Clarifiers has contained an average of only 2 p.p.m. turbidity. Not one readjustment has been needed since initial balancing.

Why such excellent results? The unique design of Rex Floctrol, by increasing mixing efficiency, produces larger, faster settling floc...saving chemicals. Rex Verti-Flo Clarifiers, an efficient system of vertical-flow settling cells and draw-off weirs, assure maximum clarifying efficiency, greatest capacity, at lowest cost.

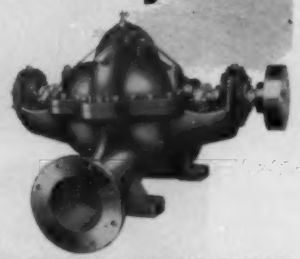
Investigate the advantages of Rex Floctrol and Verti-Flo Clarifiers. Send for Bulletin 315-51 on Rex Flocculation Equipment and Bulletin 52-77 on Rex Verti-Flo Clarifiers. Write CHAIN Belt Company, 4609 W. Greenfield Ave., Milwaukee 1, Wis.

CHAIN BELT

today there stands a city–

Where once, because there was no water, this farm failed. Helping supply water to municipalities everywhere are Peerless Type A centrifugal pumps. These horizontal work horses of the general purpose pumping field combine all the features necessary to outstanding, dependable pump performance. Split case design provides easy maintenance and inspection without disturbing piping. Superior hydraulic characteristics provide a capacity range of up to 70,000 gpm and a head range to 300 ft. A Type A's overall design efficiency and quality construction endow it first with a measurably longer service life and second with job versatility that qualifies it for nearly every pumping requirement your system may call for.

Get the finest–get the Peerless Type A horizontal centrifugal pump.



WRITE FOR BULLETIN NO. B-1300

PEERLESS PUMP

Putting Ideas to Work

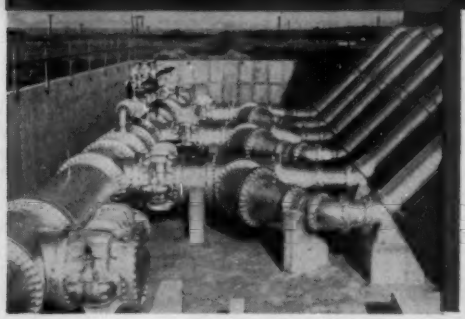
fmc FOOD MACHINERY AND CHEMICAL CORPORATION

Peerless Pump Division

Plants: LOS ANGELES 31, CALIFORNIA and INDIANAPOLIS 8, INDIANA

Offices: New York; Cleveland; Chicago; St. Louis; San Francisco; Atlanta; Plainview; Lubbock; Phoenix; Albuquerque; Los Angeles; Fresno. Distributors in Principal Cities. Consult your telephone directory.

STRENGTH PLUS



Chicago, Ill.—Cast Iron Pipe for installation of new water main under West Madison Street.

THE MAN WHO CHOOSES CAST IRON PIPE TODAY WON'T PAY FOR IT AGAIN TOMORROW!

Corpus Christi, Texas—Cast Iron Pipe installation in filtration plant showing 48" discharge manifold which is connected to 48" Cast Iron city supply line.

Cast Iron Pipe Research Association
Thos. F. Wolfe, Managing Director
Suite 3440, Prudential Plaza, Chicago 1, Ill.

MODERNIZED **cast iron**

HIGH FLOW

You get BOTH with CAST IRON PIPE

*Here's the proof of flow

FLOW FACTORS FOR CEMENT LINED CAST IRON PIPE

LOCATION	SIZE	TEST SECT. IN FEET	VELOCITY F.P.S.	AGE YEARS	W & H "C" FACTOR
Bowling Green, Ohio	20"	43,592	0.7-2.4	New	142.5
Chicago, Illinois	36"	7,300	2.6-3.6	New	147
New Orleans, La.	12"	39,630	1.5-2.9	New	141
Cordar, Mo.	8"	21,350	0.9-2.3	New	143
Univ. of Illinois	8"	400	3.14	New	130
Concord, New Hamp.	14"	500	1.7-2.2	New	151
Concord, New Hamp.	12"	500	2.0-3.4	11	142
West Palm Beach, Fla.	12"	500	3.6-5.4	15	139.5
Greenville, S. C.	30"	87,376	2.4-2.7	12	148.5
Corpus Christi, Tex.	30"	68,641	1.1-1.8	6	146
Summerville, S. C.	8"	500	1.98-2.43	13	142.5
Champaign, Illinois	16"	3,920	2.1-5.6	22	139.3

*Available upon request: Booklet containing flow test and tables on Cast Iron Pipe.

Here's the proof of strength

1. **CRUSHING STRENGTH**- . . . Standard 6" Class 150 cast iron pipe will withstand a crushing load, under standard tests, of 17,900 pounds per foot . . . important where heavy fill or shock from heavy traffic loads are encountered.
2. **BEAM STRENGTH**- . . . Settlement soil movement, or disturbance of the soil by underground construction places a heavy strain on pipe. A length of 6" class 150 cast iron pipe bears up under a load of 20,790 pounds and deflects over 2¼ inches.
3. **BURSTING STRENGTH**- . . . Tests prove that standard 6" class 150 cast iron pipe withstands internal pressure of 3000 pounds per square inch . . . providing a safety factor ample to resist high working pressures and water hammer.
4. **JOINT STRENGTH** . . . A full range of leak-proof, low cost, easy-to-assemble joints for pipe and fittings are available to meet all conditions.
5. **CORROSION RESISTANCE** . . . Cast Iron Pipe resists corrosion . . . vital factor in its proven long life and dependability.

*Based on independent laboratory tests.

pipe FOR MODERN WATER WORKS

...why didn't FORD think of THIS before?

Now that we have started making the new Ringstyle Valve for copper connections, we've wondered, too, why we didn't think of this simple idea sooner. Now that we have, a patent is pending.

Of course we were proud of the old arrangement. When we introduced the Ringstyle Valve in 1938 it was a brand new idea and the meter coupling nut attached to the valve was an important development in meter setting. But the old design, with its loose ring for connecting the valve to copper, had its disadvantages.

But look what we've done with this new one. We've built the beveled end right onto the valve itself and reversed the thread arrangement. Thus, the standard copper tube nut fits right on the new Ford Ringstyle Valve for an easy-to-make, leak-proof joint. The capacity is not reduced — The appearance and utility are improved.

Former Design

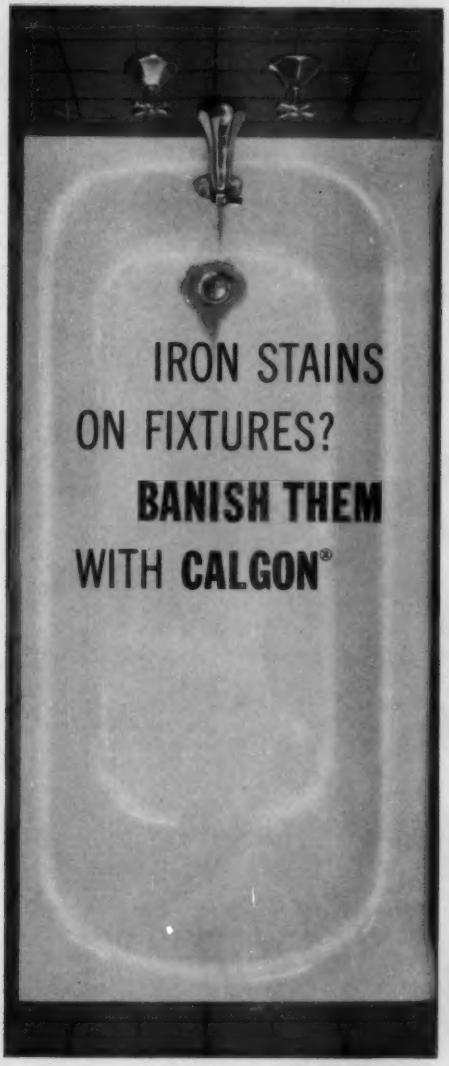
The men who install this new Ford Ringstyle Valve will certainly approve this change because there's no loose ring to drop into the mud or dirt in the ditch. Connecting the valve to the copper service line is simpler, easier and quicker.

Write for information and sample.

FOR BETTER WATER SERVICES

FORD

THE FORD METER BOX COMPANY, INC. Wabash, Indiana



Iron stains on plumbing fixtures . . . rusty streaks and spots on sheets and linens . . . small wonder housewives complain. But city officials can turn complaints into compliments by adopting Threshold Treatment* with Calgon.

Calgon is the least expensive and most convenient way of stopping dissolved iron and manganese from discoloring water . . . staining fabrics and fixtures. Used in threshold amounts (2 to 10 ppm), Calgon's sequestering and dispersing action stops the precipitation of dissolved iron and manganese often present in well waters. Calgon's film forming ability protects pipe lines, reduces corrosion and maintains pipe line capacity.

An experienced Calgon engineer will be glad to work with you on the solution of your particular water problem. Write or phone the address below:

CALGON COMPANY

DIVISION OF **HAGAN** CHEMICALS & CONTROLS, INC.
HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY, HALL LABORATORIES
IN CANADA: HAGAN CORPORATION (CANADA) LIMITED, TORONTO

*U. S. Patents 2,337,586 and 2,304,850.

TRINITY VALLEY

For All Cast Iron Water Works Fittings

AWWA Standard Bell Spigot Watermain Fittings—2" through 36".

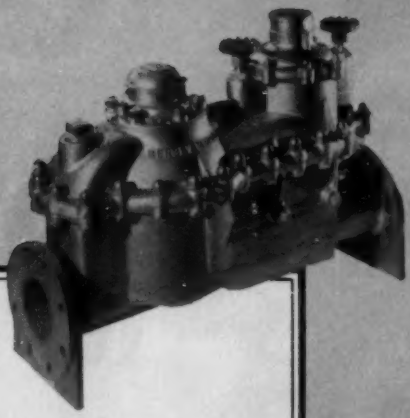
Ring Tite Fittings 3" through 16" Class 150. Class 100 through 12".

Short Body and Mechanical Joint Watermain Fittings—2" through 20".

Fluid-Tite Fittings 3" through 12" Class 150.

TRINITY VALLEY IRON AND STEEL COMPANY

Phone PE 8-1925 Fort Worth, Texas P. O. Box 664



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Registration of
all kinds of Water Services the
complete line of

HERSEY
WATER METERS

will give you the best results
at the lowest maintenance cost

HERSEY MANUFACTURING COMPANY
DEDHAM, MASS.

BRANCH OFFICES: NEW YORK - PORTLAND, ORE.
PHILADELPHIA - ATLANTA - DALLAS - CHICAGO
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NOW!

improved...
streamlined...
modernized...the

EDDY Hydrant
has ALL these features...

★ *Optional ground line break flange*
★ *Large diameter barrel for increased flow*
★ *O-ring or standard packing*
★ *New self-sealing rubber ring main valve packing*
★ *No lubrication required for fast, easy opening*
★ *Opens with the pressure—for instantaneous flow*
★ *Closes against the pressure—eliminates water hammer*

Optional break flange gives double protection against impact damage

NEW SAFETY FLANGE

NEW SAFETY COUPLING

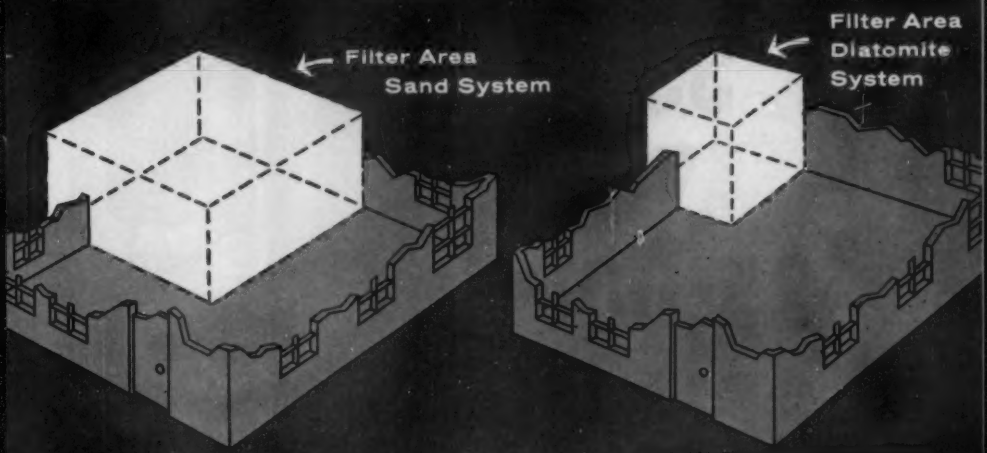
The EDDY Hydrant...improved... streamlined...modernized...retains all the basic advantages that have made these hydrants outstanding for four generations. Yet, it has important new advanced design features which provide the utmost in efficient, dependable, longlife fire protection service.

These new important advantages are provided without sacrificing interchangeability of working parts with EDDY hydrants now in service. Now, more than ever, EDDY offers maximum fire protection, economical maintenance and assurance against future obsolescence in your fire-fighting system.

Before buying or specifying hydrants, be sure you know how these advantages may benefit your community.

EDDY VALVE COMPANY
A Subsidiary of James B. Clow & Sons, Inc.
WATERFORD NEW YORK

WITH CELITE DIATOMITE FILTRATION YOU CAN GET CRYSTAL CLEAR WATER AND...



Cut space requirements as much as 75%

A Celite* diatomite filtration system requires only ¼ the housing space that a sand filtration system needs to deliver the same water capacity. Because of this, an actual Celite diatomite filter station was installed by Johns-Manville for only 55% of the cost of a comparable sand filter plant.†

For those communities that wish to increase their present water capacity but must hold down improvement costs, a Celite diatomite filter can in most cases be added right in the existing sand plant. Capacity can be more than doubled without spending a penny for additional land or construction.

Diatomite systems not only save space, but, under comparable conditions, they also improve water clarity. For with Celite, turbidity is usually lower, since more suspended impurities, including all floc, amoebae and algae, are removed. In fact in some cases, turbidity is so low it can't be measured.

Mined by Johns-Manville at the world's largest and purest commercial diatomite deposit, Celite is carefully processed for purity and uniformity. It is available in a wide range of grades to deliver the best practical balance of clarity and flow rate with any suitable filter. For further information see your nearby Celite engineer or write for free technical reprints and illustrated brochure to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

Celite filter aids are composed of microscopic irregularly shaped particles like these. 90% of a given quantity of Celite is composed of countless channels and voids that trap the finest impurities while permitting the free passage of clear liquid.

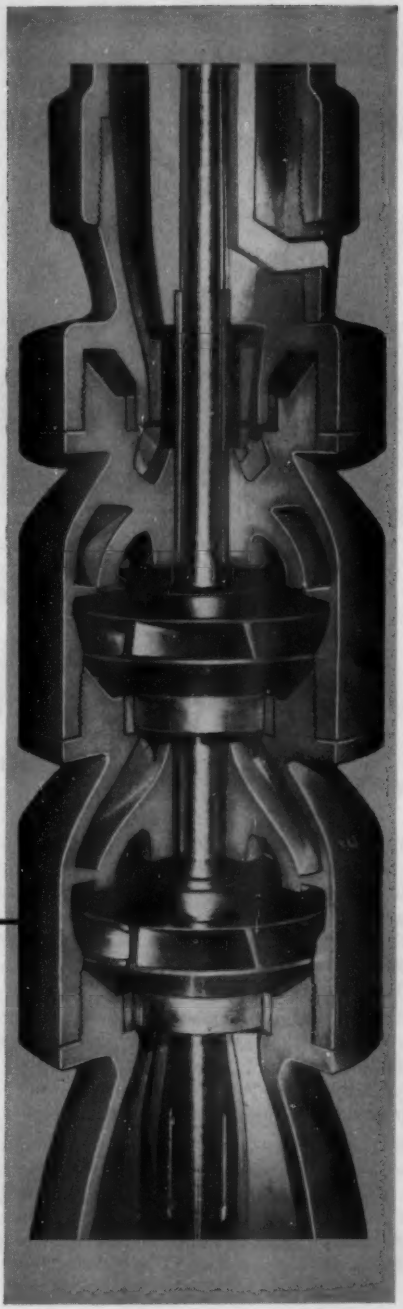
*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products. †See *Comparison Studies of Diatomite and Sand Filtration* by G. R. Bell, Journal American Water Works Association, September, 1956 or write for free reprint.

Johns-Manville CELITE Filter Aids

35 TO 25,000 GPM/LP*

Municipal water needs vary and that's why Layne produces pumps in a variety of sizes and capacities, each designed and engineered to deliver the required GPM economically and unfailingly.

Layne pumps are backed by over 75 years of experience gained around the world.



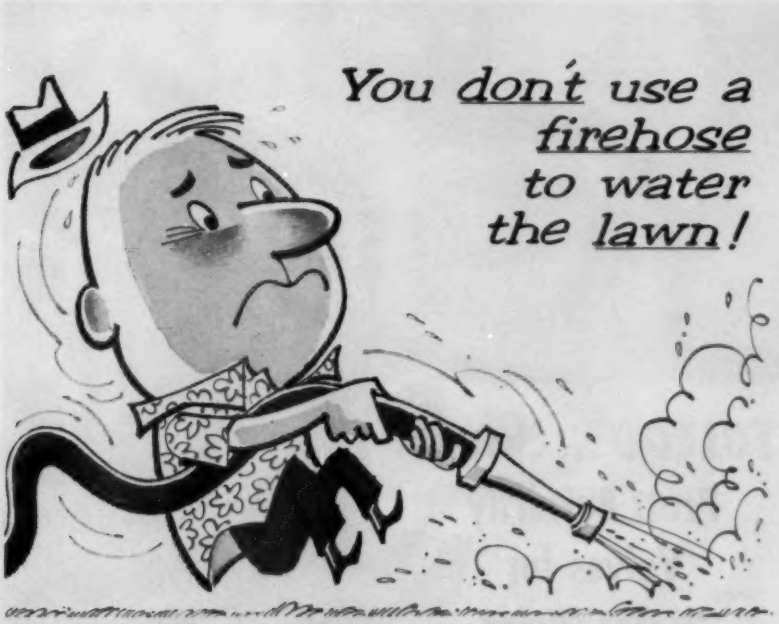
* *Gallons per minute per Layne Pump*

Write for free bulletin No. 100.

LAYNE & BOWLER, INC.
Memphis 8, Tennessee
Layne Associate Companies Throughout The World

Layne

WATER WELLS
VERTICAL TURBINE PUMPS
WATER TREATMENT



Nor need you any longer use a pipe that is not engineered to your specific requirements

Specify new, modern CEN-VI-RO Concrete Pressure Pipe

Because if, for example, the installation calls for a maximum pressure of 35 pounds, Cen-Vi-Ro Concrete Pipe can be designed for this particular pressure. The dollars saved can be put to better use elsewhere!

The simplicity and precision of the Cen-Vi-Ro joint assure faster installation under all conditions. This results in substantial savings in laying costs as well.

Investigate the unsurpassed quality, service and economy of Cen-Vi-Ro Concrete Pipe. *For courteous, expert assistance, write or contact:*

Vulcan Materials Company

Concrete Pipe Division/Telephone JAckson 4-6243
P. O. Box 6226 / Station H / Atlanta, Georgia

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Vulcan Materials Company...

Birmingham Slag Division
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"Organized for Service"

Vulcan Materials Company

Installing 48" Pratt High Pressure Rubber Seat Butterfly Valve in a Toledo, Ohio water main. Engineers: City of Toledo Water Department; George Van Dorp, Chief Engineer.

TOLEDO... Chooses Pratt Butterfly Valves for Water Mains

Long after this valve is buried, in six months or sixty years, it will still be **easily opened or closed by one man using a standard tee-wrench.** Pratt Valves are designed to give the kind of honest dependability you need for water main use... the disc edge is corrosion-resistant and seats accurately in a rubber liner made extra-heavy to prevent permanent set. The one-piece stainless steel valve shaft rotates in lifetime lubricated bronze bearings, and the operator is permanently lubricated and sealed to withstand seepage.

In 1956, the City of Toledo purchased 13 Pratt Rubber Seat Butterfly Valves for its water mains, in 24", 30", and 48" diameters. All of them were designed for buried service without protective vaults around valve or operator, **adding substantial savings in installation costs** to their freedom from maintenance problems.

Pratt engineers stand ready to help you select valves for distribution service or any water works application. Call on them with your next valving problem.

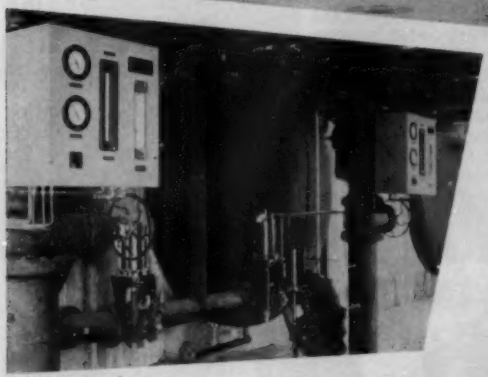
Have you sent for your copy? . . . of Pratt's 40 page Manual of Rubber Seat Butterfly Valves. Useful — contains latest pressure drop and flow data, conversion tables, butterfly valve theory and application.
Catalog B-2C.

HENRY PRATT — RUBBER SEAT Butterfly Valves

Henry Pratt Company, 2222 S. Halsted St., Chicago 8, Ill. Representatives in principal cities

Multi-Cell FILTERS CUT COSTS

ask



This 18 MGD pressure iron removal plant serves 2 refineries, a Navy Base, a Paper Mill and the City of Anacortes, Washington.

Designed by Carey & Kramer, Seattle, it is the largest of its kind ever built. One pushbutton initiates the backwash cycle for the entire plant.

Low construction costs and simple operation are the bonus features you experience when you select a MULTI-CELL filter system for removal of iron and manganese.

May we show you how other cities have solved their supply and expansion problems with one or more MULTI-CELL package plants.

GENERAL FILTER CO.

WATER PROCESS ENGINEERS

P.O. BOX 350 AMES, IOWA

YOUR BEST BUY

for top performance, long life, low upkeep . .

Leopold

WATER PURIFICATION AND FILTER PLANT EQUIPMENT

LEOPOLD GLAZED TILE FILTER BOTTOMS

• Permanent • Can't corrode • Acid and alkali-resistant • Not subject to tuberculation • Proved in over 375 plants with a daily capacity of over 2¾ billion gallons.

LEOPOLD FIBERGLASS-REINFORCED PLASTIC WASH TROUGHS

• Require no painting or other maintenance • Easy to handle —inexpensive to install • Resist weather, last indefinitely • For all design requirements • Also ideal for weir plates, collector troughs, baffles, etc.

Whether adding new plant capacity or modernizing present facilities, it pays to use Leopold Filter Plant Equipment. Leopold products can't be beat for efficiency, long life, and overall economy. Any way you judge them, they're your best buy. Just mail coupon below for details.

LEOPOLD RUBBER-SEATED BUTTERFLY VALVES

• Provide positive bubble-tight closure • Designed for quick installation, easy operation, minimum upkeep.

LEOPOLD FILTER OPERATING TABLES

• Over 2000 in service • Standard or special models for individual needs with electric, hydraulic or pneumatic indicators. Also hydra-pneumatic control systems.

LEOPOLD DRY CHEMICAL FEED MACHINES

• Available in three capacities for volume batch feeding of dry chemicals.

Leopold also manufactures flash and vertical-shaft type mixing equipment.

MAIL COUPON TODAY FOR LITERATURE— COMPLETE DETAILS!

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Zelienople, Pa.

Gentlemen:
☐ Please send literature on complete line of Leopold products.
☐ Please have representative call.

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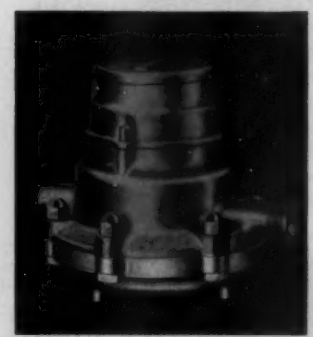
Affiliation_____

City_____ Zone____ State_____

THE WATER COMMISSIONER

Guardian of The Public Water Supply



American Frost Bottom Meter has frost separable gear train and chamber.

He Says, ***"American Meters help us build for the increased water demands of the future by bringing in full revenue for water used today!"***

The major responsibility of the water commissioner is an adequate supply of pure water. He knows that one of the best ways to safeguard an adequate water supply is to eliminate waste and to get a full return for water delivered.

American Meters insure full revenue, because they register accurately—even trickle flows. The secret of this accuracy is the design of the measuring disc to form a more efficient seal... another example of American advanced engineering. That's why so many Water Commissioners everywhere buy American!

BUFFALO METER CO.

2914 Main Street • Buffalo 14, New York

NEW from ORANGEBURG

A SUPERIOR 75-POUND PLASTIC PIPE

No pinholing—It's completely slit-proof!

75-Pound Orangeburg SP Plastic Pipe—like Heavy-Duty Orangeburg SP Plastic Pipe—is made from a superior new-type resin.

Its molecular weight—which governs toughness and strength—is at least 30 times higher than other types.

To you, this means performance you can rely on to do the job better. 75-Pound Orangeburg SP is approved for drinking water service by the National Sanitation Foundation. It's ideally suited for well pipe, irrigation lines and other water services.

On your next job use 75-Pound Orangeburg SP and be sure. If your wholesaler does not have it in stock, a shipment can be made within one day.

Only 75-Pound and Heavy-Duty Orangeburg SP Plastic Pipe give you the advantages of this new slit-proof, pinhole-proof, high-molecular-weight resin. Its quality is backed by Orangeburg, a great name in pipe for 65 years.

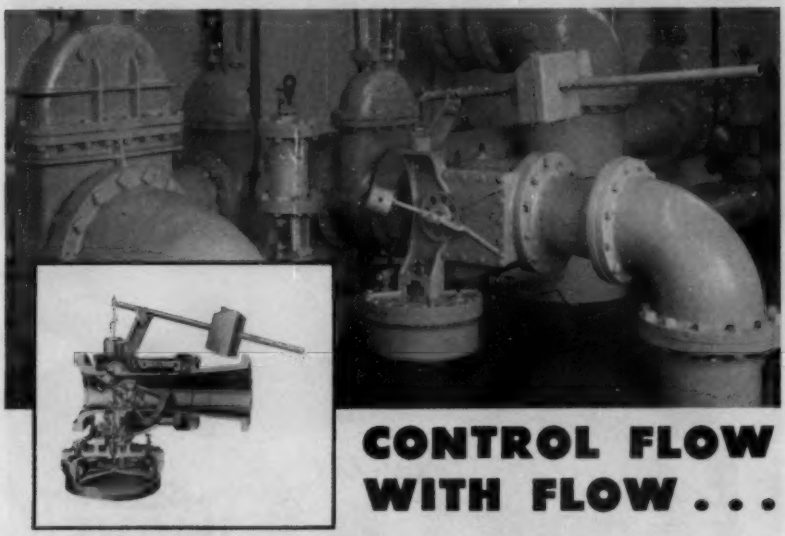
ORANGEBURG MANUFACTURING CO., INC., Orangeburg, N.Y. ...Newark, Calif.

ORANGEBURG®
***SP* Plastic Pipe**

NSF APPROVED FOR DRINKING WATER SERVICE BY NATIONAL SANITATION FOUNDATION

Orangeburg SP Plastic Pipe is spirally wrapped in heavy kraft paper for convenient handling, clearly labeled and provided with a convenient rip cord for easy removal of wrapping. Sizes ½" to 2" in standard coil lengths.

POSITIVE CONTROL OF MATERIALS IN MOTION



CONTROL FLOW WITH FLOW . . .

Builders Model RCE Rate-of-Flow Controller is Powered by the Flow it Controls!!

When other controllers stop . . . due to electrical power failure or interrupted air supply . . . the **reliable Model RCE** will continue to function! Another Builders progressive-design bonus!

In addition . . .

- **Costs less to install** . . . it just bolts into the line.
- **Permits flexible piping layouts** . . . compact . . . does not require long runs of straight pipe upstream or downstream . . . available in right-hand, left-hand, straight-through, or elbow types.
- **Costs less to maintain** . . . has ball bearings or knife edges at all friction points . . . plus packless construction.
- **Has lasting accuracy** . . . within ±3% over a control range of 25% to 100% of maximum capacity.
- **Available in 3" to 24" standard pipe sizes** . . . handles flows ranging from .04 to 36 mgd — for . . .

— controlling the effluent flow from a gravity sand filter.
— limiting flows to municipal subdivisions or industries.
— waterworks service (clear well level systems, filter level and master control systems).

Request Bulletin 600-G6A! Write Builders-Providence, Inc., 365 Harris Avenue, Providence 1, Rhode Island.

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DIVISION OF
B-I-F INDUSTRIES
METERS FEEDERS CONTROLS

TAPPING MACHINES

It Pays to Buy

HAYS®

- Modern Improved Design
- Designed for the Man in the Ditch
- One Third Lighter
- Easier to Handle
- Easier to Operate
- Speedier Operation
- Use with Any Standard Make of Stops
- See for Yourself What it Will Do for You

MODEL B ALUMINUM ALLOY TAPPING MACHINE

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MAIN DRILLING MACHINE

CORPORATION STOP

ROUNDWAY CURB STOP

Join the A. W. W. A. HAYS is one of the eleven Charter Members of the Manufacturers Section of the American Water Works Association.

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WATER WORKS PRODUCTS

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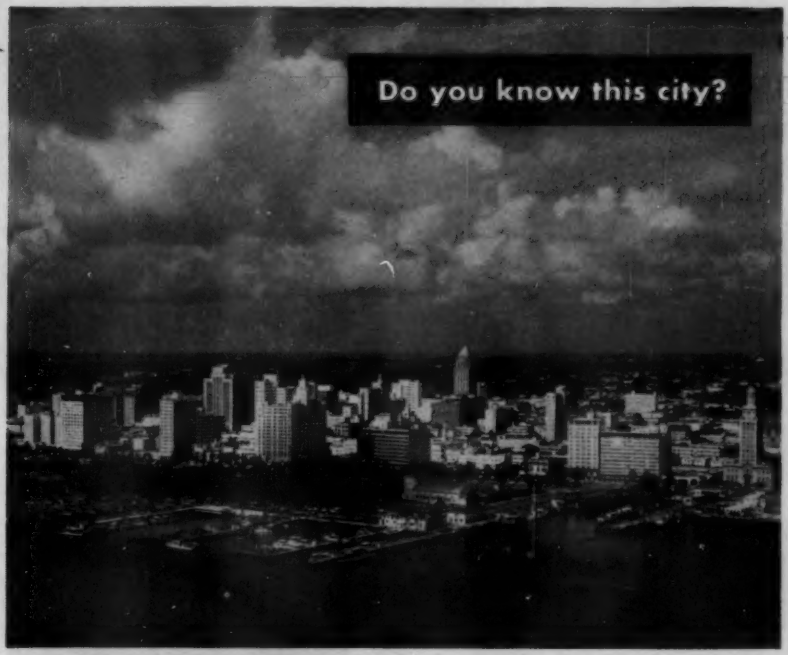

DE LAVAL *water works pumps are community "servants" in . . .*

Miami . . . The rapid growth of this famous resort city has called for dependable community "servants", such as De Laval water works pumps. These centrifugal units have given excellent performance in year-round service.

Today, in fact, the great majority of American cities use De Laval centrifugal pumps. Their design and manufacture are the result of more than 57 years of experience. Units ranging up to 100 million gallons per day are available to meet all water works requirements.

Write for your copies of De Laval Bulletins 1004 and 1005 giving data on these pumps

DE LAVAL *Centrifugal Pumps*

DE LAVAL STEAM TURBINE COMPANY
822 Nottingham Way, Trenton 2, New Jersey

DL 4084

AMERICAN FERROFILTER

Installation of "American" Ferrofilters and "American" Double Suction Split Case Pumps at Columbus, Indiana Water Plant • Consulting Engineers, Henry B. Steeg & Associates, Inc., Indianapolis, Indiana.

Independent tests and observations of "American" Ferrofilter operation at the Columbus, Indiana water plant show reduction to .15 ppm on 1.8 MGD loading/filter. (Units are rated 1.5 MGD.) Even on excess loading of 2.5 MGD/filter with all six wells on, iron reduction was still getting down to .2 ppm.

The "American" Ferrofilter is a contact filter that offers many advantages as a complete process or as a preliminary process—for the removal of iron, manganese, carbon dioxide, and other dissolved gases and odors, in one simple operation. It combines fundamental processes and design in an effective and economical treatment plant. Utilizes fine media in open aeration. Can be backwashed to remove any excess accumulation, leaving the filter in condition for another cycle. In most cases, it eliminates the need for a sedimentation tank or sand filter.

Write for Bulletin No. 252B or for specific information relating to your application.

Utilize our experience in engineering design and manufacture of field-proved equipment and pumps for water and waste treatment.

AMERICAN WELL WORKS

IN OUR 50TH YEAR
112 North Broadway
AURORA, ILLINOIS

Pumping, Sewage Treatment, and Water Purification Equipment
RESEARCH • ENGINEERING • MANUFACTURING

Offices: Chicago • New York • Cleveland • Cincinnati • Kansas City • Sales Representatives throughout the World

ALCO *steel mains with high-carrying coal-tar-enameled inside surfaces help New York City distribute over a billion gallons of water per day.*

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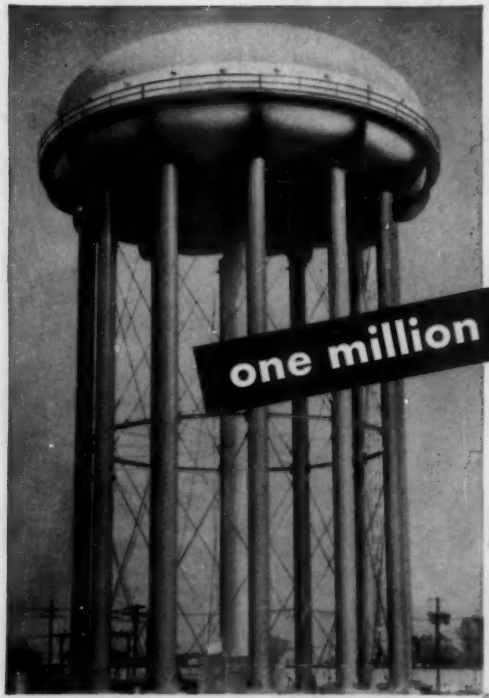

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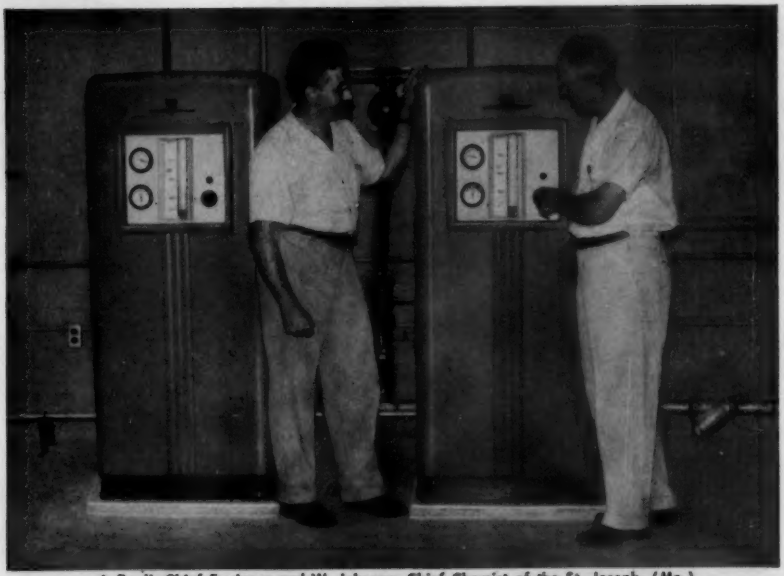

J. Pauli, Chief Engineer and W. Johnson, Chief Chemist of the St. Joseph, (Mo.) Water Company, discuss operation of their W&T V-notch chlorinators. The St. Joseph Water Co. is part of the American Water Works Service Co., Inc. system.

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Development Plans for the Sabine River Watershed

John W. Simmons

A paper presented on Apr. 22, 1958, at the Annual Conference, Dallas, Tex., by John W. Simmons, Exec. Vice-Pres. and Gen. Mgr., Sabine River Authority of Texas, Orange, Tex.

THE watershed development program in the Sabine River Valley of Texas and Louisiana is now in its tenth year. In 1949, the 51st Texas legislature created the Sabine River Authority of Texas as an agency of the state, and empowered and directed it to control and use Sabine River water —including storm and flood water for the performance of those functions authorized by the constitution of Texas. These include use for domestic and municipal purposes, for irrigation, industry, navigation, recreation, and the generation of hydroelectric power. In addition, the authority was authorized to encourage and develop drainage systems and a program of soil conservation. It was empowered to make contracts with persons, corporations, municipalities, the state of Texas, the state of Louisiana, and the federal government in order to carry out the purposes for which it was created.

Initial Planning

Immediately after the first organizational meeting of the board of directors of the authority, it became apparent that a long-range plan of action was an absolute necessity. In accordance with the directives in the legislative act and the powers given by it to the authority, initial planning revolved around three basic considerations: [1] the proper way to develop the Sabine River Basin, [2] financing of such a program, and [3] the approach which would protect the interests of Louisiana and Texas.

It was decided that three major undertakings needed to be accomplished as integral parts of an overall development program. A policy was established that basin-wide development be followed as the most desirable means of insuring full conservation for the benefit of users in every part of

the watershed. To implement this, the first point specified establishment of a master plan of development that would include all available data on the river basin—such as details of topography, geography, rainfall, stream flows, and other aspects—which would determine location of dams and reservoirs to provide maximum conservation.

Because the authority was organized to function without taxing powers and, thus, could operate solely on the basis of revenues, the second point proposed that a thorough study be made of ways

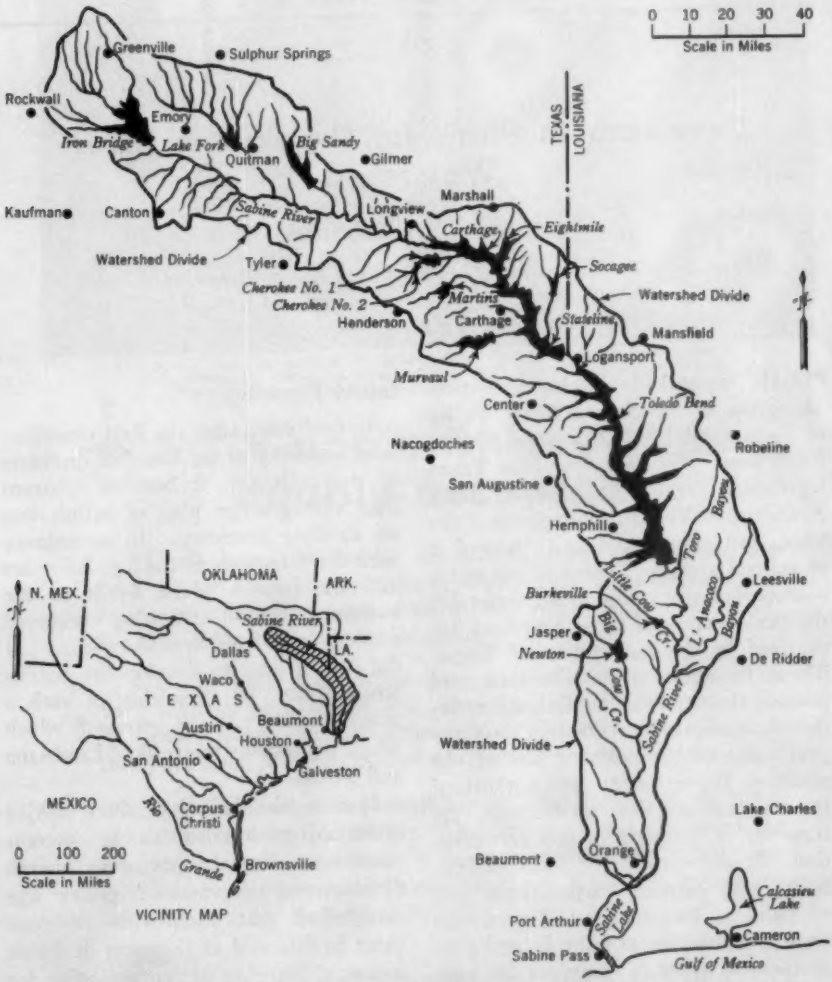

Fig. 1. Sabine River Watershed

Shaded portions are of areas to be occupied by reservoirs proposed in master plan.

and means of financing the program to be developed and that concentrated efforts be made to obtain a source of funds on which to operate independent of legislative appropriations.

In order to insure protection of the rights of the two states involved, the third point recommended that negotiations be started with the ultimate goal of a compact between Texas and Louisiana for the equitable apportionment of the Sabine River waters.

During the first organizational year, most of the work was devoted to planning and study.

With basic policies established by the board of directors, steps were taken to obtain professional and technical consultants considered essential to get the projected plans under way. A contract was made with a firm of consulting engineers for preparation of the master plan as well as for engineering related to the proposed compact and general authority operations. A general counsel was retained for legal advice and assistance in all matters relating to programing, compacts, and operations. A contract was also made with a syndicate of board counselors for assistance and advice on all matters relating to financing and the issuance and sale of revenue bonds.

The authority's consulting engineers were directed to start immediately on the collection and evaluation of all available data relating to the river, its tributaries, and the watershed in general and to assemble for consideration recommendations for the maximum utilization of waters with maximum conservation.

Texas-Louisiana Compact

Shortly after the creation of the Texas authority, Louisiana created by legislative act a counterpart, empowered similarly, and designated as the agency to develop the Louisiana portion of the watershed and thus the agency with which the Texas authority would compensate in all matters related to the development of the watershed.

In 1951, the two authorities appeared before Congress and requested permission to begin negotiations for a compact between the states for the apportionment of waters from the Sabine River. The act granting this permission was passed by Congress and signed by the President in November 1951. Under its provisions, a commission of negotiators was provided, to include a governor-appointed representative of each state and a representative of the United States—to be named by the President.

The initial meeting of the commission was held in February 1952. Legal and engineering advisory committees were appointed to include representatives of the three agencies concerned. A schedule of work to be performed was adopted and a timetable of progress agreed upon. After 1 year of work—during which seven commission meetings and eleven advisory group meetings were held—the compact was signed in January 1953. It was ratified by the Texas legislature in April 1953; by the Louisiana legislature in May 1954; and by Congress in August 1954.

It is not possible in this report to present a detailed resume of the compact. Salient points, however, are as follows:

1. Texas has free and unrestricted use of all waters above the state line, but must provide a minimum flow at the state line of 36 cfs.

2. Water stored in reservoirs above the state line is recognized as Texas water.

TABLE 1

Data on Reservoirs Proposed in Master Plan for Sabine River Watershed

Reservoir	Stream	Drainage Area *sq mi*	Allocations of Storage *acre-ft*			Average Reservoir Inflow *cfs*	Yield From Individual Reservoir *cfs*	Yield From Reservoir System *cfs*
			Dead Storage	Water Conservation	Total Storage			
Upper Basin Area								
1. Iron Bridge	Sabine River	752	27,400	772,600	800,000	472	296	
2. Lake Fork	Lake Fork Creek	506	10,000	165,000	175,000	309	96	
3. Big Sandy	Big Sandy Creek	216	10,000	190,000	200,000	172	86	
4. Eightmile	Eightmile Creek	111	10,000	150,000	160,000	88	58	
5. Martins	Martins Bayou	129	5,000	60,000	65,000	103	34	
6. Murvaul	Murvaul Bayou	133	10,000	150,000	160,000	106	60	
7. Socagee	Socagee Bayou	101	10,000	150,000	160,000	81	54	
8. Cherokee No. 1*	Cherokee Bayou	131	11,700	50,700	62,400	129	79†	
9. Cherokee No. 2	Cherokee Bayou	119‡	0	61,000	61,000	undetermined	underetmined	
10. Carthage	Sabine River	3,770	25,000	500,000	525,000	undetermined	undetermined	1,068§
11. Stateline	Sabine River	4,775	25,000	500,000	525,000	undetermined	undetermined	1,437‖
Subtotal			144,100	2,749,300	2,893,400			
Lower Basin Area								
12. Toledo Bend	Sabine River	7,130	1,300,000	3,500,000#	4,800,000	5,791	2,673	3,261**
13. Newton	Big Cow Creek	115	7,000	43,000	50,000	undetermined	undetermined	
14. Burkeville	Little Cow Creek	70	5,000	25,000	30,000	undetermined	undetermined	
Subtotal			1,312,000	3,568,000	4,880,000			
Total			1,456,100	6,317,300	7,773,400			

* Site developed by private capital. † From combined storage of both Cherokee Bayou sites. ‡ Included in the 131 sq mi of Cherokee No. 1 reservoir.
§ With upstream reservoirs No. 1–3, 8, and 9 in operation. ‖ With upstream reservoirs No. 1–10 in operation. # For water supply and hydroelectric power.
** With upstream reservoirs No. 1–11 in operation.

3. All free water—that is, water not previously stored in reservoirs above the state line by Texas—shall be divided equally between the two states, without reference to origin.

4. Each state may construct reservoirs on the river or its tributaries located wholly within its boundaries, with appropriate deductions or additions being made on the state's share of tributary storage below the state line reach.

5. Waters stored in reservoirs constructed by the states in the state line reach shall be shared in proportion to contributions to cost of storage. Neither state may construct state line reach reservoirs without the consent of the other.

6. The states may construct jointly reservoirs in the state line reach with revenues therefrom being proportional to contributions to the cost of construction.

7. A Sabine River compact administration with representatives from each state and the United States is established in the regulatory interagency body for the enforcement of the provisions of the compact.

Master Plan

While work was progressing on the compact, consulting engineers for the Texas authority were proceeding with preparation of the master plan of development. After several years of research and field work, a comprehensive plan for the entire basin was approved by the board of directors in January 1955 and, immediately thereafter, it was filed with and approved by the Texas State Board of Water Engineers.

Figure 1, a watershed map of the Sabine River Basin, shows the fourteen reservoirs included in the plan, four of which are main stream reservoirs and ten of which are on tributary streams. Also shown is the stream on which each is located and its drainage area. Table 1 summarizes pertinent data on these fourteen reservoirs. Particularly significant points are:

1. Storage in the upper basin area of the river amounts to approximately 3,000,000 acre-ft in eleven potential reservoirs with a dependable yield of approximately 2,500 cfs at state line reach.

2. Lower river (bistate) storage is approximately 5,000,000 acre-ft with a dependable yield in excess of 3,000 cfs.

3. Total basin storage approaches 8,000,000 acre-ft, with a dependable basin yield of approximately 5,800 cfs.

Financing of Canal Purchase

During the period when work was being pursued on the compact and the master plan, investigations were also being pursued of means whereby the authority might achieve financial independence. From the time of inception until 1954, the authority had operated on appropriation loans and advances from the state legislature. In July 1954, after months of negotiation, the authority acquired the physical properties of an Orange County, Tex., canal company which had provided water for industrial plants and rice irrigation. In order to finance this purchase, the authority issued and sold $1,100,000 of revenue bonds. This sale made possible the repayment to the state of $65,000 previously advanced. Total assets of the system at the close of the last fiscal year—Aug. 31, 1957—amounted to $2,058,725.89. Principal and interest payments on the bonded indebtedness have been made on schedule. Income over and above debt serv-

ice is used to defray maintenance and operation expenses of the canal system and for authority development and planning expenses.

The abovementioned canal system, composed of a pumping plant and 132 mi of gravity-flow canals, is operated as the Orange Canal division of the authority. The new office building of the division also serves as general headquarters of the authority.

dous possibilities for watershed water conservation.

During 1954, formal discussions were started with the Dallas long-range water committee regarding the Iron Bridge dam and reservoir, and exploratory conferences were continued with representatives of the Louisiana authority on the Toledo Bend project.

Because one project—the Orange Canal system—was already in opera-

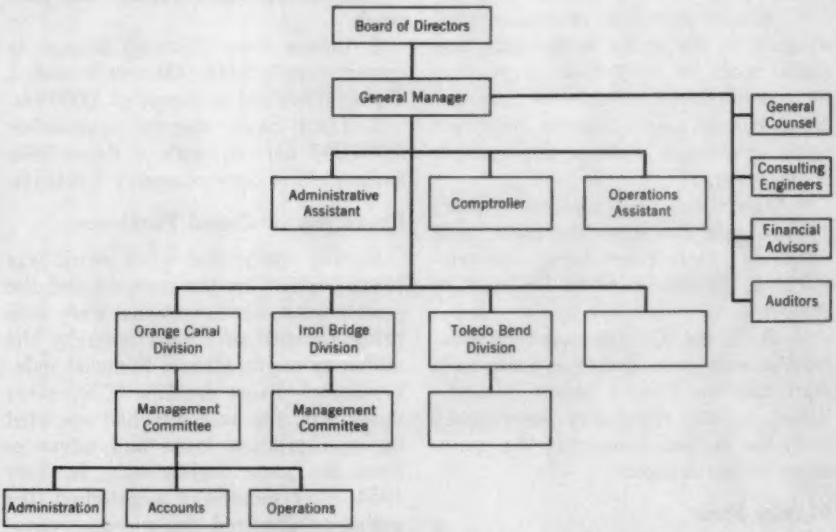

Fig. 2. Organization of Sabine River Authority of Texas

Plan is of the authority as it is now operating.

Subdivision of Operations

At the same time that work was being consummated on the purchase of the canal system, there were new developments on two other major projects. Although the master plan had not been formally adopted, preliminary studies indicated that two reservoir projects—the Iron Bridge site in the uppermost region of the watershed and the Toledo Bend site in the bi-state lower region—offered tremendation and, in anticipation of accelerated developments on the other two, it was decided to subdivide authority operations by decentralizing routine management responsibilities. This was done in order to promote efficient performance in the widely diversified activities.

The Orange Canal division was the first created by the board of directors and came into existence when the canal system was purchased. The division was set up to function under a manage-

ment committee composed of several directors, with the general manager serving as chairman. It was to operate as a separate entity which would be integrated into the overall authority program through the board of directors.

Concurrently with the establishment of the Orange Canal division, the managerial framework was established for the Iron Bridge and the Toledo Bend divisions. In time, these projects grew in a manner which justified division organization and operation. Figure 2 shows the permanent plan of organization of the authority as it is now operating.

Iron Bridge Project

The Iron Bridge dam and reservoir project developed rapidly after the initial meeting with the Dallas long-range water committee. After it had been determined that the project was feasible from both engineering and economic standpoints—at a cost of $20,000,000—and would provide an excellent source of water to help meet the future requirements of Dallas, a contract was negotiated with the city. This provided that the authority would finance, construct, own, maintain, and operate the reservoir and that Dallas would pay 100 per cent of the cost and receive 80 per cent of the water—160 mgd—in perpetuity. In the ensuing months, the authority obtained a permit from the state board of water engineers and the contract was ratified by the voters of Dallas.

In August 1956, the Iron Bridge division office was opened in Greenville, Tex. Since that time, the authority has issued and sold $5,000,000 in revenue bonds for the project. Under the terms of the contract with Dallas, these bonds are a guaranteed obligation of the city and are to be paid out of city water department revenues as an operating expense. The remaining $15,000,000 of the cost of the project will be provided by Dallas through the sale of revenue bonds.

By April 1958 more than 60 per cent of the required 50,000 acres of land had been purchased; the headquarters building and maintenance shops had been completed at the reservoir site; an 8,000-ft portion of the earthen dam had been finished; and the final contract for completion of the dam, spillway, and outlet structures had been let with work then in progress. Agreements had been executed with the Texas highway department for construction or relocation of reservoir roads and bridges for which the authority is contributing $1,300,000.

In contracting with Dallas to give the city permanent rights to 80 per cent of the water, it was the feeling of the board that the remaining 20 per cent—40 mgd—would provide adequately for the long-range needs of the cities in the reservoir area. When this water has been fully committed to municipal and industrial users, the surplus revenues therefrom will be used to assist in financing two other tributary reservoirs to augment further the water supply in the area of the upper river. When completed in 1960, the entire project will be owned and operated by the authority—with Dallas contributing a minimum of 80 per cent of the cost of maintenance and operation.

Joint Project

Three cities are currently negotiating for permanent raw water supplies from the reservoir. The authority has agreed to finance the required pumping facilities and pipelines if these municipalities desire it.

The remaining major project now under active consideration—the Toledo Bend dam and reservoir in the state

line reach—is a joint undertaking of the authorities of Texas and Louisiana.

Shortly after the compact between the states was ratified, the two authorities contracted with consulting engineers for a preliminary report on this project. The report, accepted in May 1955, concluded that more detailed studies and cost estimates were justified on the basis of the initial work.

At present, a detailed feasibility study is being made at a cost of $150,000, which funds were obtained jointly by the authorities as a planning advance from the housing and home finance agency of the federal government.

The authorities are continuing to meet and have already established the location of the dam, spillway, and power plant facilities. In the meantime, the legal and financial advisory groups of the two states are working on the means of handling the multitude of problems attendant to this multimillion dollar bistate project. Private power companies serving the area have been informed of all developments and it is planned to wholesale the power developed to such private utilities.

It is anticipated that the feasibility study will be completed in July 1958. The report will contain topographic surveys; geologic and soils investigation data; hydrology and dependable water supply forecasts; data on power potential and value; and design studies and cost estimates for dam spillway and power plant. It will also include relocation cost estimates; probable land appraisal and acquisition costs; and overall project cost estimates.

When the report has been accepted and a definite course of action established, the authorities, acting through the engineering, legal, and financial consultants will set up the necessary procedures for negotiating power contracts, for revenue bond and state assistance financing and for preparation of projects plans and specifications.

Conclusion

In general, the work on the five major projects of the Sabine River authority of Texas has consisted, thus far, of the planning and establishing of organizational procedures for the future. Much of the work will require many, many years before the final objectives of complete and coordinated development of the river and its tributaries are reached.

Currently, the authority is negotiating with five municipalities in the watershed and cooperating with three local water supply districts.

Negotiations are underway with the municipalities for contracts that will provide for present and long-range water demands. In three instances, water will be supplied from the Iron Bridge reservoir. In the other two, reservoirs will probably be constructed in conformance with the master plan.

For the local water supply districts, the authority has expressed and shown full cooperation, even to the advancing of planning funds. The only stipulation is that projects constructed by agencies other than the authority must conform to the master plan.

Progress to date would certainly seem to indicate the workability and desirability of divisional operations.

In the final analysis, none can be positive about developments in the Sabine River watershed in the years to come. It is believed, however, that the concept of basin-wide development is proved by the work to date to be the only equitable and financially feasible way of developing a great watershed basin.

Development and Use of the Potential Water Resources of Illinois

William C. Ackermann

A paper presented on Mar. 26, 1958, at the Illinois Section Meeting, Chicago, Ill., by William C. Ackermann, Chief, State Water Survey, Urbana, Ill.

WATER resources and related matters have become a popular subject, and are discussed by a wide assortment of individuals and groups, including both amateurs and professionals. One type of amateur, who might be called the headline hunter, is the least informed and is causing the greatest concern, in some cases near-hysteria, by crying that the water table is falling, the streams are drying up, and that generally the country is running out of water. It is often implied that water resources are greatly diminished and that America is thereby facing a crisis. This implication may attract a great deal of attention, but it unnecessarily alarms many people. Another outspoken group includes the professionals, or water resources experts, who generally state that demand is approaching supply and, consequently, water laws must be changed. For Illinois, and possibly for other states in similar circumstances, the author believes that this is poor advice.

Potential Water Resources

Water resources in Illinois, which are as great today as when the area was a wilderness, stem originally from a great river of atmospheric moisture. It is presently estimated that this great current brings over the state some 2,000 bgd. From this source, the rather inefficient processes of nature cause only about 5 per cent to fall as rain or snow. Yet this mere 5 per cent averages about 100 bgd in Illinois. After deducting the presently uncontrollable losses of evaporation and transpiration there remains some 25 bgd of usable water in the form of stream flow or ground water. Present use, including municipal, industrial, and agricultural uses, is about 8 bgd, although consumptive use is much smaller as there is a great deal of industrial reuse of water.

Admitting that this is an oversimplification, it does indicate a present theoretical margin of 3 to 1 in favor of supply. Added to these internal resources of stream flow and ground water formidable reserves exist around the state border. In California, engineers transport Colorado River water 350 mi across rugged desert and mountain terrain. Illinois has the Mississippi River along its western border, which carries several times the flow of the Colorado, and is no farther than 210 mi from any part of the state. Similar parallels could be drawn with respect to the Ohio River, the second largest river in the United States in terms of discharge. Lake Michigan supplies a considerable segment of the state's population, with water which, along with direct lake diversion,

amounts to about 2 bgd. The action of the US Supreme Court on Mar. 3, 1958, indicates that this source is not likely to be withdrawn, and may reasonably be expected to be increased somewhat.

If, to the 25 bgd of runoff within the state, the minimum flow of record on the Mississippi River at Keokuk and the minimum flow of the Ohio River at Metropolis are added, the mean daily total available to Illinois is 41 bgd. By adding the present diversion and pumpage from Lake Michigan, the grand total mean available is about 43 bgd. This increases the theoretical supply-to-use ratio in Illinois to more than 5 to 1.

This brief summary of potential water resources has one purpose: to establish that Illinois is a water surplus state and not a water deficit state. There is no need to become hysterical and start rationing. So far as meeting present water supply and industrial needs, or providing for a considerable expansion in present uses, it would seem that Illinois has the basic raw material to do this.

Illinois Water Law

This great and renewable natural resource of water only becomes real if the right to use it is granted. This is where water laws come into the picture. Water laws in Illinois are typical of those which, until recently, were generally applied in all the 31 humid eastern states of this country.

Illinois law recognizes three categories of water and applies somewhat different laws to each: [1] ground water, [2] diffused surface water, and [3] water in natural watercourses. A recent study (*1*) states:

> The Illinois law of ground water rests on a single case decided in 1899 which places us "in the list of states following the English common law." In the basic case the court held that "Water which is the result of natural and ordinary percolation through the soil is part of the land itself and belongs absolutely to the owner of the land, and, in the absence of any grant, he may intercept or impede such underground percolations, though the result be to interfere with the source of supply of springs or wells on adjoining premises."

With respect to diffused surface water flowing over the land Illinois adopted early the law of natural drainage which derives from the old Roman code. The Illinois Supreme Court has stated in *Gormley* v. *Sanford*, 52 Illinois 158, 162 (1869):

> As water must flow, and some rule in regard to it must be established when land is held under the artificial titles created by human law, there can clearly be no other rule at once so equitable and so easy of application as that which enforces natural laws . . . for each successive owner takes whatever advantages or inconveniences nature has stamped upon his land.

The Illinois principles of natural drainage as applied to diffused surface water are roughly as follows:

1. A lower landowner must receive surface water flowing naturally from higher ground.
2. A landowner may drain surface waters into watercourses.
3. A lower landowner has no right to obstruct the flow so as to interfere with the drainage of higher land.
4. A landowner may collect surface water, discharge it, and hasten its flow to lower ground, if good husbandry requires it. This is of particular signifi-

cance, as it applies to surface impoundments such as farm ponds.

With respect to water in natural streams and rivers, it is clear that Illinois is committed to a system of riparian rights, and apparently the courts have incorporated the theory of reasonable use. The principles of riparian rights include these points:

1. Everyone through whose land water naturally flows may enjoy the privilege of using it. The right to use depends upon riparian ownership of land along the stream and is not a property right in the water itself.

2. Priority of time in using the water confers no exclusive right.

3. Reasonable use determines the extent of the riparian owner's property right.

4. Under the riparian doctrine water uses are divided into natural and artificial uses. There is a fine point of particular interest: "Natural uses represent needs that must be supplied if man is to exist—drinking purposes, household wants, and water for his cattle or stock (*1*)." For such purposes a riparian owner may take all of the water he actually needs. On the other hand, artificial uses are those which supply the comfort and increase the prosperity of the landowner, such as irrigation or industrial applications. "Water for artificial uses must be on a reasonable basis and one owner can not deprive another of a proportionate use of the water for this purpose (*1*)."

5. Irrigation is not a natural water use in Illinois. It is on the same footing as industrial use.

Under these laws Illinois has developed its great water resources, and this has been an important element in its outstanding economic development. The state has not suffered from a lack of water as a consequence of these laws, and there has been an almost complete absence of legal controversy. Illinois water laws are based on the theory of plenty, which has been true in the past, and the author does not think that this situation has suddenly changed.

Arguments for Change

The seventeen western states of this country are essentially water deficit states. Their principal use for water is for irrigation. They have much more available land than water, however, and so water must be dispensed on a first-come basis. (This is the law of prior appropriation, which is frequently stated as "first in time is first in right.") Under this system the courts have been choked with legal tangles between neighbors, between communities, and between states.

With their growing use of water, and fanned by concern and near-hysteria, eastern states are moving toward the western type of law. Mississippi has adopted an appropriation law (*2*), and other states have adopted a modified form of appropriation in which new or added water use requires a license or permit. People are asking, and many more will ask, if other states should follow this example.

The desire for a change in water laws in the midwestern and eastern states from riparian rights and common law comes from agriculture. The reason seems clear: If irrigation becomes generally profitable, or perhaps even essential to economic survival in the highly competitive farming enterprise, the farmer will do everything he can to obtain the necessary irrigation water. Under the traditional water laws of the East, the farmer is

clearly at a disadvantage in obtaining water for irrigation, particularly surface water from streams. In the first place, few farmers are riparian owners along streams with flow sufficient to meet irrigation requirements. The farmer, therefore, would like water use detached from riparian ownership and placed on a basis of beneficial use, with the kind of built-in assurances that come with a prior-appropriation system granting water rights in perpetuity. Second, under existing Illinois law only a reasonable use can be made of the water and it must be substantially returned to the stream. Irrigation is largely a consumptive use; much of irrigation water is used up in evaporation and transpiration and, therefore, cannot be returned to the source. Thus, it is not adaptable to the reasonable-use theory which applies to the artificial uses of streamflow. The irrigation, as a consequence, would be subject to injunction and damage suits from downstream riparian users. The irrigation farmer must bring the water to his farm, and in this respect he is much less flexible than industry, which can generally locate on riparian land along a river.

In many of the eastern states, and particularly the southeastern states, irrigation has been demonstrated as a wise insurance against crop failure and has proved generally profitable because of increased yields. In those states, the practice has spread rapidly and pressure for a change from riparian and common law to an appropriation system has been in proportion.

The experience of Illinois has been quite different, and farmers by and large have not found it profitable to irrigate. For this Illinois can thank its generally ample rainfall and its heavy black soil, which has immense water-holding capacity. Thus far only one farm in 500 in Illinois has tried irrigation, and it has been applied to only about 17,000 acres. Most of this has been on specialty crops such as gladiolas, seed corn, and horseradish. Virtually all the corn and soy beans of Illinois are grown with the moisture which nature places in the soil. The clear feeling of the author is that, barring a major shift in Illinois' cropping systems or a complete change in its economic balances, irrigation will not become widespread in this state. For a fuller discussion of the pros and cons of irrigation, see Reference *3*.

Development Factors

Thus far, this discussion has been primarily a defense against extremists who claim Illinois has virtually exhausted its water supplies and those who urge rationing dwindling reserves by means of an appropriation law. There are positive actions or programs which can be carried out to complement rather than change existing laws. The author will list five points which are of critical importance:

1. *Maintain a strong program for the collection of basic data related to water resources.* Without information as to the location, quantity, and quality of water resources all other activities will fail. This includes geologic mapping, ground water exploration and studies, stream flow measurements, and studies of chemical water quality, sedimentation, evaporation, and rainfall and other meteorological phenomena. It is largely such programs which have brought Illinois to its present high stage of water resource development.

2. *Maintain a forceful program of pollution control.* This is not only es-

sential to the health of the state, but also to the economic development of its water resources. If sanitary, chemical, and temperature wastes are not controlled within reasonable limits at the sources, the reuse of water, which is an absolute necessity, will be either impossible or economically unattractive—which in the long run amounts to the same thing.

3. *Accelerate research on conservation methods.* Economic alternatives will then be available to water users as their use approaches the limits of present or existing supplies. The reference here is to ground water recharge, suppression of evaporation losses, methods of water recirculation and reuse, and the development of treatment methods to restore or retain water quality within acceptable limits.

4. *Build adequate facilities to develop, treat, and distribute water resources, based on realistic financing.* When the causes of water shortage problems of the drought period of 1952–55 are analyzed, it is found that, usually, it was not so much a failure of Illinois water resources as inadequate design to bridge a period of minimum flow of that duration. A standby well or a larger storage reservoir, if present, would often have prevented the shortage. In this same category can be included full metering and elimination of leakage in the distribution systems.

5. *Guide the location of heavy water-using industries into areas of adequate water supply.* If a large water-using industry exhausts an otherwise adequate supply, no one profits. Channeling use into areas of sufficient supply is the responsibility of state agencies concerned with industrial development, and also of local communities.

Additional Steps

There are two additional steps which Illinois should seriously consider for early activation:

1. The existing State Water Resources and Flood Control Board should be activated by the appropriation of funds for it to become an active planning agency. Illinois does have research programs and regulatory agencies, but no agency presently is in a position to carry out comprehensive water resources planning, which might lead to an Illinois water plan.

2. Illinois should consider either active participation in water resources development or assistance to local communities in the development of water facilities which are consistent with the master plan. This would permit coordination throughout the state with both local and federal programs. It would make it possible for the state to contribute to federal project planning, rather than being in the present "take-it-or-leave-it" situation. The experience of two other states can guide Illinois. California has developed a water plan which will ultimately cost the state 12–14 billion dollars, and is moving to implement this plan with an active program of design, construction, and operation that will require appropriations on the order of $100,000,000 annually. Texas, as another example, is also developing a master water plan and has established a revolving fund of $200,000,000 to be loaned to local agencies for the construction of water supply facilities.

Summary

The full and effective development of water resources is a matter of great importance. The author has tried to show that there is a large water resource potential in Illinois, and to suggest that this can best be developed under existing water rights laws. The state must, however, continue strong programs of basic data collection, pollution control, water conservation research, adequate facilities, and location of users. State participation in water resources planning and assistance to local communities should be considered.

Acknowledgment

In the section on Illinois water law the author has drawn heavily upon the recent and excellent study by John E. Cribbet, Professor of Property Law at the University of Illinois (*1*).

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Mississippi Water Rights Law

Jack W. Pepper

A paper presented on Oct. 21, 1957, at the Mississippi-Alabama Section Meeting, Biloxi, Miss., by Jack W. Pepper, Water Engr., Miss. Board of Water Comrs.

MISSISSIPPI, with an annual rainfall of almost 60 in., until recent years was more concerned with flood control and drainage than with water conservation. An article written in October 1950 states (*1*):

> Irrigation, which has long been practiced in the arid West, is now practiced in some areas of Mississippi in connection with rice growing and to supplement rainfall during periods of deficiency. All irrigation water is drawn from ground water supplies. However, if the practice becomes widespread, it might be necessary to use surface streams at a future date.

These remarks show that the use of water for irrigation in Mississippi was just beginning in 1950; since that time it has increased at an alarming rate. Since the end of World War II, the industrial development in Mississippi has been greatly increasing the demand for water, and even more will be required in the future.

In 1953, some of the people of Mississippi, aware of the increased competition for the use of water and the possibility of water shortages in some areas, formed the Mississippi inter-organizational committee on water resources. As a result of the work of this committee, with the cooperation of agencies and individuals, a report was published in December 1953 (*2*). The cost of printing this report was paid by the thirteen organizations making up the committee.

This report convinced the legislature that there was an immediate need for further study. Legislation creating the Mississippi Water Resources Policy Commission and appropriating funds for its operation was therefore passed.

The same groups that assisted the Inter-Organizational Committee worked with this Policy Commission and helped it to prepare a report (*3*). After the report was published the legislature followed its recommendations, and on Apr. 6, 1956, the Water Rights Act (House Bill 232) was passed.

Previous Practice

The previous water laws of Mississippi were developed in the early days, when settlers used the rivers for navigation, fishing, and domestic purposes. These uses tended to keep water in the streams. The first laws adopted in Mississippi were based upon the common law of England. The part of this law which is of primary interest is the riparian doctrine.

Riparian property is property that actually abuts on a natural watercourse or lake, or land through which a natural watercourse passes. The vast majority of the property in a city would be nonriparian land; lands separated from streams by public roads would probably be declared nonriparian.

Under the riparian doctrine, a person owning riparian property is entitled to the use of the water flowing by in its natural current or channel, undiminished in quantity and unimpaired in quality. The important thing that is often overlooked is the fact that the riparian owner has no property in the water iself, but only a simple right to use it as it passes along.

The main fault in the riparian doctrine lies in the fact that under it the water resources of the state cannot be utilized to their fullest extent. Even though modern courts have adopted the principle of "reasonable use," water still could not be used on nonriparian land. The amount considered reasonable was a question of fact for the courts to decide, and even this amount varied as conditions changed. In irrigation, for example, a person could invest thousands of dollars for equipment to irrigate and as others on the stream began to increase their uses of water, the investor's water rights might be reduced to the point where they would not justify his expenditure for the equipment. This could also apply to industrial use of water.

These are factors that could discourage investment depending on use of the natural flow of the streams. It is another story for the man who wants to construct a dam to catch the flood waters during the winter and spring to use during the dry periods of the summer and fall.

Municipal water supplies are of vital interest. An example that occurred in Arkansas will, therefore, be relevant: A city used water from a creek for its municipal supply and constructed a dam to impound the water. Some of the farmers upstream later began using water from the creek for irrigation. Of course, at the time they needed water for their crops the creek was at its lowest, so the municipal water supply was reduced below the amount required to meet normal demands. When the city administration went to court to get an injunction to force the farmers to stop using the water for irrigation, it was surprised when the judge ruled that the city was a nonriparian owner and had no right to object to these upstream landowners' use of the water for irrigation. An even bigger surprise was in store a few days later, when some of the downstream riparian owners got an injunction that required the city to release the water supply stored in the reservoir in the creek.

It is true that some municipalities use ground water, and thus avoid this problem. Most little towns may be able to use their ground water supplies for many years, but many of them will have to investigate surface sources some day in the future, if the growth of municipalities proceeds as it is expected to.

Water Rights Act

Mississippi took a big step when the Water Rights Act was passed on Apr. 6, 1956. It became the first of the 31 humid-area states to adopt the principle of water appropriation. Mississippi has received national recognition for its work in the field of water legislation, and the Water Rights Act is being studied by many other states—even some of the western ones.

In its declaration of policy, the act states:

> The general welfare of the people of the state of Mississippi requires that the water resources of the state be put to beneficial use to the fullest extent to which they are capable, . . . and that the public and private funds for the pro-

motion and expansion of the beneficial use of water resources shall be invested to the end that the best interest and welfare of the people is served.

It further states that:

. . . Water occurring in any watercourse, lake, or other natural water body of the state, is hereby declared to be public water and public wealth of the state and subject to appropriation in accordance with the provisions of this act.

The effect of this legislation on riparian rights should be examined. The Water Rights Law does not take any rights away from a person. On the contrary, it recognizes some definite rights for persons owning property along a stream:

1. The act states that the Board of Water Commissioners cannot approve the appropriation of water below the established average minimum flow. This will protect the low water flows, so that the riparian owners can have the benefit of the water flowing by their property, without having the stream dried up by future upstream water users.

2. The domestic uses of the riparian owners are recognized, and the act gives a very broad definition of domestic uses. Nothing in the act will interfere with a person's right to use water for domestic uses.

3. The new law recognizes a person's right to construct a dam on streams, so long as it does not interfere with water rights below the dam. This was not possible under the old common law, and the development of many streams was, therefore, prevented.

4. The act allowed a riparian owner to use water from a stream without a permit from Apr. 6, 1956, to Apr. 1, 1958. Persons who used water prior to Apr. 1, 1958, can file their claims to have their water rights established, and continue using water to the maximum extent used in any one year.

5. Even if a riparian owner failed to use water before Apr. 1, 1958, he still has the advantage of being able to apply for a permit to use a definite amount of water. Thus, he can justify investment of the capital required to finance his operations.

6. All persons or municipalities which used surface water prior to April 1958 can establish their rights to continue using water to the maximum extent used in any one year. The Board of Water Commissioners will furnish an order of determination that can be filed in the office of the chancery clerk.

The act also stipulates that permits will be required for use of water after Apr. 1, 1958:

1. Before any additional water is used after Apr. 1, 1958, it is necessary for the prospective user first to make an application for a permit.

2. The board will grant the permit if it can normally be expected that there will be sufficient amounts of water in excess of the established minimum flows, as well as the amounts required for the prior appropriators.

3. When the surface water supplies are insufficient for additional suppplies, the applicant may construct a dam to impound flood waters to use during the dry period.

The Water Rights Act regulates use of water for municipal supply:

1. Municipal users of surface water have their rights established for the maximum amount used in any one year prior to Apr. 1, 1958.

2. Permits for municipal use are slightly different from those for other uses. After a permit is granted, the water must be put to use within a reasonable length of time. This time

interval can be as much as 20 years for municipal users.

3. After all of the requirements set forth in the permit have been met, the board will issue a license.

Priorities

These water rights are important, mainly, because they provide means for an orderly development of the surface waters. A system of priorities determines the distribution of the supplies. When water supplies are insufficient to meet the demands, the lower priorities must yield in order for the higher priorities to be fulfilled.

Priorities are not based on the purpose for which the water is used. The four major types of water use, agricultural, industrial, municipal, and recreational, are all recognized on an equal basis. The Water Rights Act is not specific about priorities for uses that began prior to Apr. 6, 1956 (effective date of the act), but the priority for all uses that begin after that date will be determined by the date that the use begins. Priorities for permits that will be issued by the board after Apr. 1, 1958, will be based on the date that applications for the permits are received in the office of the board. The priorities could be summarized as: first in time, first in right.

There are no restrictions as to the amounts of water that may be used for domestic purposes, or the time during which it may be used. The board can, in times of emergency, relax the regulations which govern the use of established average minimum flows for domestic and municipal purposes.

Summary

To determine how the water resources of an area may be used for the maximum benefits, source of supply must be examined. All stream flow originates as rainfall. Flood waters which are caused by stream flow may be utilized by impoundment, which is now recognized under the Water Rights Act. After the flood waters have run off into the Gulf of Mexico, the flow of the stream is sustained by ground water spilling over from the underground reservoirs that are recharged with rainfall. It is at this period that water supplies sometimes become critical. This is the water that requires close management, and that is of utmost importance to the welfare of the people of Mississippi. Supervision of the distribution of this water will assist in its orderly use, but this is only part of the job.

Since water is a limiting factor to the entire economy, the state must not be satisfied until it has increased the available supplies during periods of low flow, to meet all future demands. This may be difficult from an economic standpoint, but it is now legally possible. There are methods of increasing the available supplies through proper management: [1] by preventing all wasteful uses, or methods of use; [2] by preventing pollution; and [3] by soil conservation practices that will increase the ground water recharge.

The new law does not apply to ground water rights or usage. Nevertheless, the board's recommended program for ground water legislation will be of interest. At this time too little is known about Mississippi ground water supplies for the board to make recommendations for legislation. The board in its biennial report will request that the legislature make a substantial increase in the appropriation for ground water research.

In order to secure an inventory of the water resources at a more rapid

rate, the report also will request legislation that will require drillers' logs to be filed with the board. It may be necessary to make this a requirement for a driller's license, in order to assure compliance.

Mississippi has been working with this new law for a little more than 1 year, and to the surprise of many people, including some of the ones that helped draft it, very few points have been found that will require changes or clarification. The state can be proud of the work that has been done in the field of water legislation. With the continued support of the people and the water experts, Mississippi can continue to take the steps necessary to utilize its most valuable natural resource.

References

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2. *Beneficial Use of Water in Mississippi.* Mississippi Inter-Organizational Com. on Water Resources (Dec. 1953).
3. *Water for the Future in Mississippi.* Mississippi Water Resources Policy Com. (Oct. 1950).

Revision of Butterfly Valve Standards

Several changes in the AWWA Standards for butterfly valves (C504—rubber seated; C505—metal seated) were approved Sep. 16, 1957. Shortly thereafter, on Jan. 26, 1958, both documents were advanced to Standard status without further revision. In C504, the sections principally affected are Sec. 9—Valve Seats and Sec. 12—Operators. In C505, the major changes are in Sec. 12—Operators. The two standards have been redesignated C504–58 and C505–58, respectively.

Preparation, Control, and Accounting Methods of the Akron, Ohio, Water Utility Budget

Wendell R. LaDue

A paper presented on Jan. 17, 1958, at the In-Service Training Course for Water Works Supervisors, at Michigan State Univ., East Lansing, Mich., by Wendell R. LaDue, Supt. & Chief Engr., Bureau of Water Supply, Akron, Ohio.

THE Akron, Ohio, water supply system includes: [1] two impounding reservoirs, with a third under construction; [2] considerable watershed land purchased for future reservoir purposes; [3] a treatment plant and pumping station delivering the water a distance of 11 mi to the city distribution system; [4] a distribution system consisting of almost 800 mi of mains; [5] several repumpage districts, each with a pumping station and elevated storage. The water is delivered to about 80,000 customers through services installed by the utility to the property line, at the customer's expense. Meters are furnished and installed by the utility without cost to the customer.

The author is the manager of the Akron water utility. He reports to the director of public service, who in turn reports to the mayor. The funds of the utility are administered by the director of finance of the city and purchases are made by the city purchasing agent.

Budget Problems

A budget is a plan of expenditures to be incurred during a particular period and the income for financing them. Too often when laymen, and some water management officials, speak of the budget they neglect or ignore income. Income is an essential item of the budget; without its inclusion expenditures have no meaning.

Budget making and budget control are subject to the many variations, established by state authority, to which water utility managers, and those trusted with control, must conform. The finance director of the political subdivision also determines many factors of the budget and its control, to which the manager of the municipal water plants must conform in order that the utility budget will conform to and complement the city budget. There is considerable turnover among fiscal officers, who are usually political appointees, each with his own idea as to procedural details. The result is often discouraging to water utility managers who desire and need a continuing financial record of the management of the utility.

Private and Municipal Utilities

It may make a considerable difference whether a water utility is privately or municipally owned. Privately owned utilities are subject to state control of their rate structure by commissions. Consequently, budget and accounting are closely supervised as to budget control and observance and accounting procedures. A munici-

pally owned utility is sometimes supervised even more closely and often than a private utility. If it is not, however, then state supervision may vary, from simple audit to check expenditure and financing methods, to the utility submitting a report in the same form as is required for privately owned utilities.

When only general supervision is exercised by the state, local laws will require that the municipally owned utility budget tie in with the city budget, principally because the ownership of the property and the backing for the investments for this property generally lie with the city. In some instances, authorities may be established with independent fiscal responsibilities. If the water utility's fiscal matters are a part of the city's financial pattern, the utility manager's concern and responsibility for the financial aspect of the utility grows as its size and complexity increase. Often there is a tendency to restrict and detract from his responsibility by transfer of the commercial and financing functions to the city finance and purchasing organizations. There may also be a constant pressure in effect to divert the utility funds for non-utility purposes, and to assign utility personnel to perform tasks for so-called related city work. In this case, the utility manager must be on his guard to prevent impairment of his ability to operate the utility properly. The manager should insist upon receiving sufficient funds to function adequately.

Income and Expenditure

Income may be derived mainly from four sources:

1. *Sale of water.* Sale of water is the main source of revenue. It is a most unpredictable source, and to a great extent may be out of the control of the water utility manager. In the Midwest, weather conditions in the summer affect sales of water; a wet or a cool summer may cut deeply into the estimated income. In an industrial city the general national economy, continuity of industrial production, and labor relations have considerable effect on the utility's income. The rate schedule, while subject to change, should assure and produce, on an average, adequate funds over a period of years, despite fluctuations. It is not feasible or reasonable to make frequent rate changes, as is done in commercial business, nor is it good public relations.

2. *Reimbursement for recoverable expenses.* Recoverable expenses include expenditures for consumer services and possibly meters, when furnished and installed for the property owner by the utility. This item is relatively small, perhaps 10–15 per cent of total income, and can be adjusted frequently to meet the changes in cost of these items.

3. *Miscellaneous.* Miscellaneous income includes rents, interdepartmental sales and services, interest on operating cash or unexpended bond funds in the bank, sale of materials, and other small items of other than water income.

4. *Sale of bonds.* Premium and rate of interest reflect the income from bond sales required for interest and bond-retirement payments.

Expenditures may also be divided into four main classifications:

1. *Operation and maintenance.* The items which should be listed under this classification would seem to be clear. The manager must be on his guard, however, in the interpretation of periodic expenses which some may consider maintenance and others as replacement which is to be charged to

outlay in the absence of an actual depreciation reserve. Water-main rehabilitation by cleaning and lining is an example.

2. *Recoverable expense.* Recoverable expenses for consumer services and meters are offset by reimbursement, as previously noted.

3. *Plant expansion.* Plant expansion may be financed either by bond-fund expenditures or by outlay from annual income from sale of water. In the latter case, this expenditure is a pay-as-you-go, year by year, safety valve use of periodic surplus funds over a fixed, minimum reserve. These funds automatically provide a reserve for unusual expenses or a decrease in sales, and forestall a demand for a reduction in rates. They may be considered a depreciation fund for that part of the system for which bonds are not being retired, as this money is being plowed back into the system. Plant expansion funds may be considered a bonus in the unusual case of a system which does not need expansion or replacements. This bonus might be used for a rebate on one round of billing. That, however, is a dangerous device as it might spark a drive for reduction in rates.

4. *Capital expense charges.* Capital expense charges are interest on bonds and notes sold for plant expansion and improvement, and funds for bond and note retirement. Retirement of the bonded debt is essentially a depreciation item. When the bonds for plant expansion or replacement are completely retired, the expansion is depreciated to its estimated life. Retiring bonds, coupled with cash payments into a depreciation fund, is a dual demand on the finances of the utility and cannot be readily justified.

Budget Preparation

After the budget is fixed, the approved budget should be presented and accepted before the start of the fiscal year. Too often a water department budget is considered a part of the general city budget, resulting in a lag of as many as 3 months after the start of the fiscal year before acceptance. In this case, the utility works on month-by-month temporary budgets, with the result that contracts for yearly supplies cannot be entered into until nearly 6 months have passed. As the water utility budget should be entirely separate from the annual city budget, which is dependent upon current tax rates, it would be helpful to have the utility budget approved and placed in operation in advance of the general city budget. When the city budget is presented for approval, the utility budget could be incorporated as a single item without breakdown.

The preparation of the budget involves a review of the operation by the manager of the utility and the heads of the various operating departments, using financial and operational statistics for the past several years, and thereby forecasting the financial features of the coming year. This procedure involves statistics of water demand, increase in services, need for system expansion and replacements, operational and maintenance costs, and specific knowledge of future wage schedules and materials costs.

With these factors determined, a trial balance is run. Following this, adjustments are made to bring expenditures in balance with income, bearing in mind a possible use of a portion of the estimated cash surplus obtained at the start of the fiscal year. Arriving at a budget for the year and having it approved is only the beginning.

Accounting System

A water utility accounting system must at all times be under the control of the operating manager. As previously noted, the accounting system should be such as to provide the manager with a month-by-month cash picture of the financial condition of the utility. Another very essential use of this cash accounting system is in any study for rate adjustment. In this connection, a continuing breakdown of water consumption by different classes, or volume of water used by different consumers in various areas served by the utility, is not only of value in rate adjustment, but from the engineering viewpoint is essential in the study of distribution system expansion. In establishing a system of mechanical billing for Akron, this information was provided in the design of the bookkeeping machine. This system produces continuing data, and is the means by which a cash balance is maintained.

The funds on which Akron's utility operates are derived from the sale of water, and from other operations of the utility. There is no reimbursement from taxes for hydrant rental or other sources. The utility makes no contribution to the general city operation, other than rent for its quarters in the municipal building. State supervision of financial operations is limited to checks for errors or for legality of payments every 2 years.

The commercial section of the water department is divided into three subsections which deal with:

1. General customer activities, except billing and collection

2. Billing, collecting, and control of all cash receipts of the utility. Meter reading is under the supervision of the distribution section. The receipt of all funds and their deposit with the finance department is the responsibility of this subsection. Akron has a sewerage service charge and the water department acts as an agent for the city in billing and collecting this charge. The utility is reimbursed for this service. The utility and the sewerage service funds are segregated.

3. General accounting, including purchase of and accounting for material, payrolls, rents, and miscellaneous bills. This does not include billing and collection for sale of water and for service installation.

Billing and Collecting

Akron's 80,000 customers are billed quarterly. The bills carry a net and gross amount; the gross amount applies 20 days after the due date of the bill. The city is divided into nine districts with bills dated the eleventh, twenty-first, and last day of each month. The ledger-card system for consumer's accounts is used, as it is desired to maintain a continuing record of a given account, easily available for reference. This is considered very valuable as an aid to good customer relations. Each sheet contains a designation of the size of meter, which aids the biller in determining the minimum bill for the given service. Filing the ledger cards in a vertical offset file provides a means of locating unpaid accounts easily and rapidly.

Obviously, billing and collection start with the meter reader, and his route book is the initial part of the accounting system. Each route book is the primary unit of financial control, and is one day's work for the meter reader. Separation into as many as 450 units reduces the time required to keep the ledger and teller records in balance. The meter reader does not

compute the quantity of water to be billed.

To reduce the need for a second trip of the reader to those houses he could not enter, a postcard is left at the door with a request that the occupant read the meter and send the card to the office. A list of missed readings is in the route book when it is sent to the office. The route book when received is reviewed for stopped meters, and as reading postcards are received, the readings are entered on the reader's sheet. Shortly before the route is ready for billing, work orders are issued for rereads. Generally, these rereads are only a small percentage of the total number of missed readings on the original route reading.

The route book is sent to the biller, who computes the quantity of water to be billed, notes errors, bills the charges, and proves the billing on a special summary card for each route. The proved summary card is sent to the control clerk. The bill is the usual postcard utility bill, printed in two parts: an original, and a second bill used as a duplicate. This is economical as to postage, and it eliminates time that would be required to stuff envelopes. Past-due bills, however, are sent in closed envelopes.

The billing operation includes the printing of the duplicate bill at the time of printing the original. This eliminates errors that might occur in preparing bills for consumers requesting duplicate bills, and the bills sent to consumers delinquent in their payment. A large amount of time would otherwise be required to prepare these bills separately.

Cash payments made to the cashiers are balanced to the total of stubs from the receipting machines. The stubs are removed from the machine by the supervisor. Payments received by mail are checked with the corresponding stubs. The stubs are sent to the ledger posters and the receipts are deposited with the finance department daily. The posting to the ledger sheets is made on a daily cash-receipt basis from the bill stubs. This posting is checked with the cashier's cash report and stub total.

The route reports from the billers and the daily reports from the cashiers are summarized from a route control, which is consolidated into nine district controls, and finally into a system control. At the end of the 20-day net-payment period, the difference between the net and gross amounts is picked up from the ledger sheets and posted to the control. The use of vertical ledger sheets filed in offset position makes it easy to list unpaid accounts. At the same time, the duplicates of unpaid bills are pulled from the file. At the end of a 30-day period the duplicate bills for unpaid accounts are mailed. Twenty days later a final notice is mailed, and if no payment is made within 10 days a turn-off order is issued.

The preceding is a brief description of the office procedure. For those who are interested in a more detailed account, reference is made to a 1947 article (*1*). Naturally, there have been some changes in detail, but the basic system today is the same as in 1947.

General Accounting

The necessary auxiliaries to general accounting, such as payroll preparation and the recording of materials purchased and used, are a function of the subsection on general accounting. Biweekly payrolls are prepared from approved time slips for hourly rated men and from the established schedule for

TABLE 1

Classifications of General Accounting System

INCOME

A. Sale of Water

B. Reimbursement for Recoverable Expense
   1. Service installation
   2. Paving restoration due to service installation
   3. Curb meter installation

C. Miscellaneous
   1. Rent
   2. Work done for others
   3. Sale of material
   4. Miscellaneous

D. Rotary or Inventory Adjustments

EXPENDITURES

Operation and Maintenance

Salaries
Office Equipment
Office Supplies
Miscellaneous
Auto Operation
Workmen's Compensation and Retirement Funds
Taxes
Impounding Reservoirs Operation and Maintenance
Filtration Operation and Maintenance
Pumping Operation and Maintenance
Distribution System Operation and Maintenance
Other Expense
Watershed Property
New Service Installations
Miscellaneous Work for Others
Curb Meter Installations
Miscellaneous

Outlay

Main Extensions
Other System Improvement
Water Meters
Miscellaneous

Capital

Interest
Bond Retirement
Rotary or Inventory

salaried men. Earnings only are entered on the payroll sheets, which are then sent to the city finance department for making the necessary deductions and for preparation of checks. The employment status, salary, and absence records of employees are maintained by this subsection.

The procedure for purchase of supplies is:

1. A request from a section head is approved by the superintendent.
2. A requisition approved by the superintendent, the mayor, and the director of public service is forwarded to the city purchasing department.
3. The requisition is approved by the city finance director, who encumbers the proper fund.
4. The purchasing department issues the order for the purchase.
5. When the order is issued, a copy is sent to the water department to form the basis for a departmental encumbrance charge.
6. When material is received the city purchasing department is notified, and it approves the invoices and certifies them to the finance department.
7. A copy of the paid invoice and the city voucher are sent to the water department for record and accounting purposes.

Miscellaneous bills for rent, damages, and work done for others are prepared by this subdivision. The collection and recording of receipts are the responsibility of the subsection on billing, collection, and control of receipts.

Table 1 shows the major classifications of Akron's general accounting system. Each account is further detailed as deemed necessary. The administration account includes not only the ordinary accepted administrative charges, but engineering, commercial, office, and meter-reading expense.

Budget Control

Control of the budget is a year-long problem for the utility manager. Control involves a month-by-month knowledge of the cash status of the various functions involved. The financial condition of each function of the utility at the end of each month should be available to the manager not later than the fifteenth of the following month. Many budget controls by fiscal-minded personnel are not only considerably behind this schedule, but so broken up that they do not furnish the manager with the necessary up-to-date information for his control of the operation of the system. Fiscal-minded personnel often consider funds only on a yearly basis, making necessary closing-out and adjustment charges at the end of the year. The utility manager should consider his position month by month.

It is essential, therefore, that a budget control for the system on a cash basis be maintained by the utility personnel. The structure of this utility control will depend upon the system make-up, and the desire of the manager for information which he considers necessary for his control. Of course, if at all possible, this operational structure of the utility should be such that the various items can be reconciled with those of the finance department budget.

In like manner, encumbrances against the various items must be followed closely. If not, the manager may find that work will be delayed due to the fact that no funds are available, or transfer of funds is required before the given materials and equipment can be purchased or funds assigned for labor.

For adequate budget control, which is really a system of cost accounting, inventories are essential. Purchases of materials which normally would be charged directly to an account should first pass through an inventory account if such purchases are for more than a 3- or 4-month demand and are of considerable value. Examples are such items as coal, pipe and fittings, service materials, curb meter settings, and meters and meter parts. An encumbrance item is also necessary on the item of reimbursement of recoverable expense to cover the backlog of services or meters paid for but not installed. For example: water mains and services are to be installed in a real estate development or in annexed territory. Money may be received in the fall of the year, but the installations are not made until in the spring of the following year. Without an encumbrance account the recoverable operation item will show a large income-expense ratio at first, with a correspondingly low ratio later. This encumbrance is as essential as the encumbrance item for unfilled orders and contracts on the expenditure side of the budget.

Reference

1. LaDue, W. R. & Hoffman, L. J. Modernized Accounting System Installed at Akron, Ohio. *Wtr. Wks. Eng.*, **100**:1198, 1260 (1947).

Financial Problems of Municipally Owned Water Utilities

Albert P. Learned

A paper presented on Mar. 12, 1958, at the Kansas Section Meeting, Salina, Kan., by Albert P. Learned, Prin. Engr., Black & Veatch, Kansas City, Mo.

OPERATORS of municipally owned utilities seldom concern themselves with the financial problems; they are involved in the production of a commodity and its distribution, or rendering a service to fulfill the requirements of the customer. The operator realizes that a public utility should serve all who apply, supply their maximum requirements, and provide adequate service. He seldom has occasion, particularly when a rate schedule has been in force for years, to determine whether the rates create discrimination between customers, or whether the price for the commodity or service is reasonable.

Previous Practice

Operators have generally been unfamiliar with municipal utility financial problems, as they relate to the water and sewer utilities, because of early methods of financing. For instance, many of the cities in Kansas originally financed the construction of their water system by issuing general obligation bonds, the debt requirements of which were financed through general taxation, rather than payments by the customers served by the system. This method was not too unfair as originally applied, because savings in fire insurance premiums often offset a large part of the general tax paid by the customer. The customer's cash outlay was not materially affected by this method, and he had the additional benefit of a water supply for domestic uses.

Carrying the debt requirements by general taxation resulted, usually, in a rate schedule which reflected only a minor part of the total cost of service. This practice generally led to a failure to provide any annual allowance for a depreciation reserve. Many people, knowing that cast-iron mains were long-lived, assumed that the remainder of the water plant units were also long-lived, at least long enough so that there was no need for a depreciation reserve. Such a reserve would have provided funds for replacements, or for current additions; in some cases, a liberal depreciation allowance would have provided funds for use in major expansions.

Cost of Systems

Water systems vary decidedly in total cost per customer. This is vitally influenced by the cost of the supply and production elements. Low costs occur in systems where untreated well water can be secured in ample quantities at various points in the area served. Costs are much higher where the well supply is a considerable distance from the service area, and also requires treatment, or where the sup-

ply is taken from rivers and requires treatment.

When a well supply is in the service area, the supply and production plant investment is normally 15–17 per cent of the total investment; otherwise, it may be 33–50 per cent.

Effect of Increased Costs

There have been two periods since 1900 in which the cost of materials and labor has increased materially. There was an abrupt increase after World War I. Part of this increase was lost within 2 years; subsequently, there was little increase until the beginning of World War II. During World War II prices were reasonably controlled, but afterwards there were substantial increases that have continued at various rates until today. This situation has resulted in substantially higher unit prices for materials used in water systems, which affects operation and maintenance costs and the amount of capital required for current replacements and extensions. The phenomenal growth of communities, added to these increased unit prices, presents a real problem in financing.

The general municipal taxation base has not increased to nearly as great an extent as have unit prices of material and labor; the ability of municipalities to issue general obligation bonds has, therefore, decreased. In addition, other municipal functions have increased in costs. These increased costs have made it practically impossible for a city to subsidize its water system by continuing to assume the fixed charges of debt.

Revenue Bonds

The revenue bond method of financing was developed to relieve the city as a whole of the debt burden of revenue-producing utilities. It made the customers of such utilities responsible for paying sufficient revenue to cover the total cost of service.

General-obligation bonds are attractive investment items in Kansas and carry a low rate of interest, since the resources of the city are pledged to insure payment of interest and principal. Revenue bonds are protected by the income of revenue-producing utilities, and a pledge by proper officials that the rate schedules will be changed,

TABLE 1

Investment and Revenue of Electric and Water Utilities

Type of Utility	Investment†—$	Average Revenue—$		
		Per Residential Customer	Per Commercial Customer	Overall
Electric utilities*	4.21	74.83	756.93	168.50
20 private water utilities	6.34			48.62
1 large municipally owned water utility	10.00	44.90		68.63

* Source: *Federal Power Commission Statistical Report on the Operations of the Class A and B Electric Utilities* (1956).
† Per dollar of annual revenue.

if required, to insure payment of all debt requirements. In order to improve the sale and security of revenue bonds, investment bankers require a margin over and above the debt requirements, usually between 30 and 50 per cent of debt requirements, and sometimes more. A large margin ordinarily reduces the interest rate required.

Revenue bond financing makes the utility proposing to issue bonds put its house in order and determine its real costs of service. Where this has been done efficiently, it has resulted in a much healthier financial condition of the utility. The excess margin in funds over debt requirements is available to make additions to the plant, to accelerate retirement of revenue bonds, and to build up a depreciation or cash reserve.

Increased Revenue Needs

In addition to the additional revenues required to finance fixed charges of a water system, there have been substantial increases in the last decade in the cost of chemicals, labor, and materials used for maintenance and repair. These factors alone, in some instances, have required a 100 per cent increase in revenues.

The study of the rate structure to provide additional revenues has, at times, shown that the prior rate has produced discrimination between customer groups. Adjustments to produce an equitable rate structure have resulted in varying rate increases between customer groups and, in effect, within groups, depending upon the quantity of water purchased by a customer.

Some cities have found that they were overzealous in extending water mains; in certain instances the return on the investment is nothing, and may be a burden on the other customers in the system. This has usually led to the development of a wise and uniform policy in respect to the amount a municipality will underwrite in the extension of mains, and on what basis and at what time it will pay its underwriting share. The important point is that the municipality secure sufficient business from the extension to warrant its investment.

Water and Electric Utilities

There are a number of interesting comparisons which can be made between the electric and water utilities. Table 1 shows some of the differences in average revenue and in investment between these two types of utility.

The situation illustrated by Table 1 is the result of a much better annual and seasonal load factor in the electric utility business than in water utilities. This means that the fixed charges on a water system under like conditions claim a larger amount of the annual revenue than in the electric utility. It also means that under like conditions the operating and maintenance expenses of the water utility must be lower than in the electric utility.

The proper provision for depreciation may be somewhat alike in total annual amount per customer for both types of utility, because even though the annual allowance per dollar of investment is lower in the water utility, its investment per dollar of annual revenue is higher.

Sewer Systems

The sanitary sewer system with its treatment works is now generally recognized as a utility, and is almost

always owned by the municipality, in the United States. It can be said that it is a utility built to handle the spent water supply that has been used for residential, commercial, and industrial uses, and which contains wastes requiring some form of treatment for stabilization. The sanitary sewer pipe system conveys this water from the populated areas to the point of discharge into treatment works, or to a point of discharge into a stream capable of absorbing such wastes without menace to public health or creating a nuisance.

Higher standards in sewage disposal have required, in many instances, both primary and secondary sewage disposal works. Increases in the cost of operating sewer systems and sewage disposal works, and in the cost of construction of sewage treatment plants, have paralleled the corresponding increases in costs of water utilities.

The conditions that forced the water utilities to become completely self-sustaining through revenues collected from customers have compelled the use of revenue bonds for primary outfall sewers and disposal works improvements, and the assumption by the utility of part or all of the operating expenses of such systems.

In order to raise the necessary revenues, many cities have adopted a sewer rental charge. This charge has been determined by several methods, including: a percentage of the water bill, a charge for residential customers based on the average use of water during winter months, and a charge for commercial and industrial customers upon a volume basis, based on the volume of water discharged into the sanitary sewer, whether the water is secured from the municipal water system or from private sources. In some instances the single-family residence rate has been made a flat charge per month, and the multifamily residence rate a flat charge plus a volumetric charge. Where there is stronger sewage, the charges are based on the strength of the sewage. The stronger sewage has a material effect on the size of the secondary plant.

Charges

In both water and sewer rental charges, it is important that the rate schedule include a major part of the demand charges in the first few brackets of the schedule. Otherwise, the variable sales in dry and wet years might affect to some degree the financial stability of the project. In many water systems a large proportion of residential bills make only the minimum charge.

It was mentioned previously that the older method of financing had probably been quite sound in that the taxation burden bore a close resemblance to the saving in insurance rates. In view of this, when the customers have to bear the entire expense, it is more equitable if the hydrant rental is collected through taxes. This reflects, at least theoretically, the value of the property protected.

Since the financial responsibility of water and sewer systems is now charged entirely to the customers, it is imperative that such charges be equitable and capable of substantiation if questioned.

It is actually an improvement to have adequate water and sewage charges, because they enable the customer to determine what his utility service is costing him. Utility cost is not truly reflected when a portion of it is paid through taxation.

Proper charges are determined from studies of cost of service, which normally include three prime subdivisions: demand, commodity, and customer charges. In water rates, another logical subdivision would be fire protection.

There are a number of items of importance that the engineer must weigh in his analysis if he is to correctly determine the financial needs of a municipal utility and reflect them in the rate structure. First of all are the quantity requirements of the customers, their rate of demand for deliveries of such units, and their probable future requirements. Quantity requirements determine two elements: the facilities required to render the service, and the units upon which the costs are to be spread. In this connection, it is of great value if records of quantity and peak rates of use covering several years are kept, so that these factors can be correlated with rainfall and temperature records to determine what may be an average of conservative usage. Financial stability of the utility may thereby be insured.

In certain areas rainfall has an important bearing on sewer rates, because the soil is such that infiltration into the sewer is materially increased by rainfall. This element has a bearing on the design of the primary plant. Sewers contribute largely to this overload in residential areas, and the residential user must assume his proper share of such additional-capacity costs.

A careful analysis of all elements of operating and maintenance costs is essential in evaluating basic requirements, and what costs are affected, and by how much, by added consumption. For example, production and pumping costs have substantial elements which vary according to the amount of water pumped. These costs have no corresponding increase in distribution operation and maintenance, in customer costs, or in administration expenses.

Seasonal Variation

Seasonal conditions can alter water revenues to a marked degree. A recent study showed that in 2 very dry years the amount of water sold in a community was materially greater with a smaller number of customers than it was another year when the number of customers was considerably greater, but the total yearly rainfall was lower. In the year of lower rainfall, however, more rainfall occurred in the months of June, July, and August and total consumption was quite reduced.

Conclusion

Constructive financing programs require an intelligent overall approach. A recent statement by a water superintendent in a small town in Texas seems to size up the problem. He stated that the water is free, and his charges to customers only covered the costs incurred in providing the facilities and operating and maintaining such facilities to deliver the water to customers, under their requirements of quantity, quality, and points of delivery.

Revenue bond financing ordinarily limits the use of the money obtained from rates to: [1] operating and maintenance expense; [2] amortization of debt; [3] building up contingent reserves that may include emergency repair, some depreciation funds, and amounts to cover the interest and debt requirements for the next year or more; and [4] surplus. All expenditures are usually limited, so long as there are any revenue bonds outstanding, to the payment of debt and to

necessary expansion of the utility plant, provided such expansion is profitable, and is required to render adequate and satisfactory service.

Ratemaking, to effect the results desired in handling financial problems of municipal utilities, is another phase of study that requires recognition of items that have been mentioned in this article. A careful weighing of these general facts and related considerations, and the factors peculiar to a specific community will show that the rate schedule must be developed for the specific community, if it is to be sound and properly supported.

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Wisconsin Regulations on Management of Municipally Owned Utilities

Arthur P. Kuranz

A paper presented on Feb. 6, 1958, at the Indiana Section Meeting, Indianapolis, Ind., by Arthur P. Kuranz, Mgr., Water Utility, Waukesha, Wis.

IT is the opinion of the author that neither the ownership nor the operation of a municipally owned public utility of any kind or description is a governmental function. This paper will cite the laws and statutes of the state of Wisconsin pertaining to the methods which the author believes should govern the ownership and, particularly, the operation of a municipally owned public utility.

Utility Management

A Wisconsin statute (Sec. 66.068, Management) regulates the setting up of the management of a municipally owned public utility:

(1) In cities owning a public utility, the council shall, and in towns and villages . . . the board may, provide for a nonpartisan management thereof, and create for each or all such utilities, a board of three, five, or seven commissioners, to take entire charge and management of such utility, to appoint a manager and fix his compensation, and to supervise the operation of the utility under the general control and supervision of the board or council.

At this point, political groups in the municipality begin to exert a certain influence on utility affairs. Many different points of view command attention in utility management. In the opinion of the author, the basic law covering this subject would be sufficient to eliminate serious difference of opinion, if only the law were free from alteration and misinterpretation by various groups.

After creating a management authority, the municipal governing body draws up an ordinance outlining the duties of this authority. This ordinance is, in part, developed along the line of the state statutes, and enlarges upon the duties of the management authority as follows*:

Sec. 1. There is hereby created a utility commission for the city, the members of which shall be selected upon a nonpartisan basis.

Sec. 2. The utility commission shall consist of five members, who shall be the mayor† and one alderman to be elected annually by the council, and three citizen members who shall be elected by the common council at its first regular meeting after the effective date of this ordinance for terms expiring respectively 1, 2, and 3 years after Oct. 1.

* This ordinance applies specifically to the city of Waukesha, Wis.

† The Public Service Commission has drawn a model ordinance for cities, which does not permit the mayor to act on the utility commission. Its reasoning is that in his office as mayor he should not be placed in the position of judge over his own acts.

Sec. 3. As soon as possible after their election by the common council of the city and annually thereafter, the members of the utility commission shall organize by choosing from among their number a president and a secretary whose terms shall be fixed by the utility commission.

The utility commission shall meet at least once a month. Special meetings may be held at any time on call of the president and shall be held on the request of two members. . . .

Sec. 4. The utility commission shall appoint a manager and fix his compensation. He shall be the general executive officer of the utility. He shall hold office for such time as shall be determined by the utility commission and shall give a bond, conditioned on the faithful discharge of his duties, in such sum and with such surety as shall be provided by the utility commission.

The manager shall have general supervision of the utility under the direction of the utility commission. He shall engage necessary employees and agents, and fix their compensation subject to the approval of the utility commission. He shall have supervision over the buildings, grounds, machinery, pipes, and all matters connected therewith. He shall see that all laws, ordinances, rules, and regulations of the state of Wisconsin, Public Service Commission . . . and the common council or utility commission of the city as they pertain to the operation of the utility, are complied with.

The utility commission, when necessary, may utilize the services of the city engineer, city attorney, and other officials and employees on such basis as shall be mutually agreed upon, or as determined by the common council. The general fund of the city shall be reimbursed by the utility commission for the cost of the services of city officials and city employees.

The utility commission shall have power to make all necessary rules governing its own proceedings and for the governing of the water utility, which rules shall, however, not be in contravention to any laws of the state of Wisconsin or ordinances of the common council of the city.

Sec. 5. The common council of the city may order the installation of water mains and water main extensions and appurtenances thereto where such installation shall appear to be in the best public interest, and the cost . . . shall be paid by the water utility.

Sec. 6. Upon the receipt of plans and specifications and estimated costs provided by the water utility for water main extensions or water system improvement the common council of the city shall direct the installation by the water utility where the total cost of said extension or improvement shall not exceed $1,000; where the cost of extension or improvement shall exceed $1,000, the common council shall direct said construction to be accomplished pursuant to Sec. 62.15 of the Statutes of Wisconsin:

"Main extensions and improvement may be . . . directly by the utility commission and their employees where authorized by the common council by resolution."

Bookkeeping Procedures

The bookkeeping procedures used by municipal utility management and the regulation of rates should also be covered by this ordinance:

Sec. 7. The receipts of the utility shall be paid to the bonded cashiers appointed by the commission who shall turn over all . . . receipts to the city treasurer at least once a month.

Utility expenditures shall be audited by the commission, and if approved by the president and secretary of the commission . . . shall be paid by the city clerk and treasurer in the manner provided by Sec. 66.042 (3) and in the manner following: Order checks shall be issued by the city clerk upon the filing with the city clerk certified bills, vouchers, or schedules signed by proper of-

ficers of the utility commission, giving the name of the claimant or payee, and the amount and nature of each payment.

Sec. 8. The utility commission shall have general power to construct, extend, improve, operate, and maintain the public utility subject to the powers and jurisdiction fixed by the law of the state of Wisconsin, the ordinances of the city, and the rules of the Public Service Commission. It shall have the power and authority to select and recommend purchase of sites, and to make, prepare, and adopt plans, designs, and specifications for buildings, machinery, apparatus and the laying of mains and appliances required for the proper functionting of the utility.

The statute cited gives considerable latitude to the utility commission, even though parts of the ordinance apparently are controversial. On the whole, it works out quite well.

Standby Charges

One of the most important statutes covering utility income and expenditure is Wisconsin statute 66.069 (1) Charges (a). This statute was modified (Chap. 427) in 1955 to provide: "The rates may also include standby charges to property not connected but for which such facilities have been made available. . . ."

This statute, as modified, has been used in only a few small cities; however, it presents a method which, when used, eliminates assessing the property, which in reality is an irrevocable tax. The standby charge is made only so long as the property fronting the main laid in the street is not connected to the distribution system.

Expenditure and Charges

Wisconsin statutes also regulate the way in which a municipal utility apportions its income:

The income of a public utility owned by a municipality shall first be used to meet operation, maintenance, depreciation, interest, and sinking fund requirements, local and school tax equivalents, additions and improvements, and other necessary disbursements or indebtedness. Income in excess of these requirements may be used to purchase and hold interest-bearing bonds, issued for the acquisition of the utility, or bonds issued by the United States or any municipal corporation of this state, or insurance upon the life of an officer or manager of such utility, or may be paid into the general fund.

Any city, village, or town owning a public utility shall be entitled to the same rate of return as permitted for privately owned utilities.

The state statute covering the use to which the income of a municipal utility owned by a municipality may be put is quite simple and clear. In these days when revenue bonds are used to finance extension and improvement, the utility manager and his organization are kept very busy just following the provisions of the law.

Outside Service

A municipal utility may give service to persons or places outside its corporate limits:

Outside service. (a) Any town, town sanitary district, village, or city owning water, light, or power plant or equipment may serve persons or places outside its corporate limits, including adjoining municipalities not owning or operating a similar utility, and may interconnect with another municipality, whether contiguous or not, and for such purposes may use equipment owned by such other municipality.

(b) So much of such plant or equipment, except water plant or equipment or interconnection property in any municipality so interconnected, as shall be situated in another municipality shall be

taxable in such other municipality pursuant to the provisions of Sec. 76.01 to 76.29.

(c) Each village or city shall by ordinance fix the limits of such service in unincorporated areas.

Utility Taxation

Section 66.069 (1) (c) of the Wisconsin statutes requires the income of municipally owned utilities to be used first to meet "local and school tax equivalents" as well as certain other items. On Jul. 11, 1955, the State Public Service Commission issued an order proposing to establish a rule governing the method of determining these tax equivalents. A public hearing was held on Sep. 16 to consider the proposed rules. On Dec. 7, the commission issued the final order, Chap. 109, Tax Equivalent for Municipal Utilities:

PSC 109.01. *Application of rules and date when rules are required to be placed in effect.* These rules shall apply to all municipal utilities and shall be placed in effect not later than Jan. 1, 1957. Municipal utilities to which these rules apply may, if they desire, follow them before this date.

PSC 109.02. *Municipal utilities: computing tax equivalent.* The maximum tax equivalent for any municipal utility (except a sewer utility) must be determined in the following manner:

Apply the local and school tax rate [1] to the gross book value [2] of plant plus materials and supplies multiplied by the ratio of assessed value to full value [3] for the community involved.

1. For any calendar year the local and school tax rates are those rates established by local authority for the same calendar year.

2. For any calendar year the gross book value means the book value as of Jan. 1 of that year.

3. For any calendar year the ratio of assessed value to full value means the "percentage of recommended full value" of total real and personal property as shown in the *Statistical Report* for the same year submitted to the County Board of Supervisors as required by Sec. 73.06 (5), Wisconsin statutes. The same section requires the county clerk to print not less than 200 copies of such report and to deliver "a sufficient number of copies not to exceed five to each municipality requesting the same by resolution of the governing body for the use of the officials of the municipality."

PSC 109.03. *Municipal utilities: higher tax equivalents.* If a tax equivalent greater than that obtained by methods in Sec. PSC 109.01 is desired, the written approval of the commission must be obtained.

PSC 109.04. *Municipal utilities: property outside corporate limits.* Property outside corporate limits should, in all cases, be excluded in computing municipal utility tax equivalents.

PSC 109.05. *Municipal sewer utilities: exemption from tax equivalent.* No tax equivalent shall be determined for sewer utilities.

The matter of public utility taxation is very clearly spelled out; all that is necessary is to follow the law exactly. The procedure is very simple.

The PSC order cited clearly outlines the law. The order continues by defining the duties of the commission and manager. About all that remains to be done is to draw up a set of rules and regulations to put the provisions into operation. This is a matter to be taken care of by the Public Service Commission of Wisconsin, the utility commission, and the manager (*1*).

Expansion and Improvement

The matter of expansion and improvement of the utility proper is, of course, very important and must be accomplished according to the Public Service Commission rules and regula-

tions in the *Wisconsin Administrative Code—Public Service Commission—Departmental Rules for Sewer and Water Utilities,* under Chap. PSC 184.07.

The first step to be taken is to secure and implement a certificate of authorization.

PSC 184.07. *Procedure.* An application for a certificate of authorization, as contemplated by this order, shall be filed with the secretary of the commission in triplicate, and shall set out such information as will convey a full understanding of the circumstances surrounding and the reasons justifying the proposed acquisition, construction, or extension. The commission reserves the right to call for such additional information as it may deem necessary.

After this is accomplished it is necessary for the city council to create a bond ordinance to cover the certificate of authority approved by the Public Service Commission. These bonds are to be of the open-end type under the statute 66.066 (2) (b), as amended:

66.066 (2) (b) All moneys received from any bonds issued pursuant hereto shall be applied solely for purchasing, acquiring, leasing, constructing, extending, adding to, improving, conducting, controlling, operating, or managing a public utility, and in the payment of the cost of any subsequent necessary additions, improvements and extensions, and there shall be and there is hereby granted and created a statutory mortgage lien upon the public utility to the holders of the bonds and to the holders of the coupons of the bonds. The public utility shall remain subject to such statutory mortgage lien until the payment in full of the principal and interest of the bonds. Any holder of the bonds or of any coupons attached thereto may either at law or in equity protect and enforce the statutory mortgage lien hereby conferred, and compel performance of all duties required by this section of the municipality. If there be any default in the payment of the principal or interest of any of the bonds, any court having jurisdiction of the action may appoint a receiver to administer the public utility on behalf of the municipality and the bondholders, with power to charge and collect rates lawfully established sufficient to provide for the payment of the operating expenses and also to pay any bonds or obligations outstanding against the utility and to apply the income and revenues thereof in conformity with this statute and the ordinance, or the court may declare the whole amount of the bonds due and payable and may order and direct the sale of the public utility. Under any sale so ordered, the purchaser shall be vested with an indeterminate permit to maintain and operate the public utility. Any municipality may provide for additions, extensions, and improvements to a public utility owned by the municipality by additional issue of bonds in the manner herein provided; but such additional issue or issues of bonds shall be subordinate to all prior issues of bonds which may have been made hereunder, *provided a municipality may in the ordinance authorizing bonds hereunder permit the issue of additional bonds on a parity therewith.* Any municipality may issue new bonds in the manner herein provided and secured in the same manner, to provide funds for the payment of the principal and interest of any bonds then outstanding.

Whenever it is determined by the local utility commission that expansion and improvement work cannot be financed by funds accumulated from earnings, application is made as outlined in the statutes. If the work is carried through as provided little difficulty will be experienced.

A bond ordinance must at present be obtained by asking the governing body of the municipality to set up an ordinance and conduct a bond sale, the pro-

ceeds of which must be used *only* for expansion and improvement of the utility, as provided in Sec. 66.066 (2) (b), statutes of the state of Wisconsin. The bondholders can demand through court action that the utility be compelled to follow the provision of the statutes or, if there is any default, the court may appoint a receiver of the utility on behalf of the municipality and bondholders to collect rates lawfully established sufficient to provide for the payment of the operating expense and also to pay any bonds or obligations outstanding against the utility. The court may also apply the income and revenues in conformity with the statutes and ordinances, and may order and direct the sale of the public utility.

Conclusion

The most important statutes covering the operation of a municipally owned utility and the expansion and improvement of that utility have been cited in this article. There are other statutes dealing with special matters, and each should be dealt with as a separate subject. As is the case with so many laws, any answer that may be desired can be found, and the interpretation will rest with the person using it, unless there are very specific court rulings or decisions.

Reference

1. KURANZ, A. P. Wisconsin's Policy on Municipal Utility Taxation. *Jour. AWWA*, **49**:1369 (Oct. 1957).

Emergency Use of Reclaimed Water for Potable Supply at Chanute, Kan.

Dwight F. Metzler, Russell L. Culp, Howard A. Stoltenberg, Richard L. Woodward, Graham Walton, Shih Lu Chang, Norman A. Clarke, Charles M. Palmer, and Francis M. Middleton

A paper presented on Apr. 22, 1958, at the Annual Conference, Dallas, Tex., by: Dwight F. Metzler, Chief Engr.; Russell A. Culp, Chief, Water Supply Sec.; and Howard A. Stoltenberg, Chief Chemist, Water & Sewage Lab., all of the State Board of Health, Topeka, Kan., and Richard L. Woodward, Chief, Water Supply; Graham Walton, Sr. San. Engr.; Shih Lu Chang, Surgeon; Norman A. Clarke, Sr. Scientist; Charles M. Palmer, Resident Biologist; and Francis M. Middleton, Scientist Director, all of the Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio.

THE increasing use of water and the attendant problems of providing additional supply have given rise to much speculation and discussion regarding the possible future use of sewage treatment plant effluents and other waste waters as supplemental sources of public water supply. A number of industries presently treat and recycle waste waters or use municipal sewage to conserve water or reduce stream pollution, or both. Few cities, if any, have practiced recycling of their own sewage for use in public water supply systems, although a great many do draw water from rivers containing large quantities of sewage discharged by upstream cities. Heavily polluted waters have been successfully purified in properly designed modern water treatment plants (*1*). To some few persons who are, perhaps, overly imbued with a sense of local pride, this seems to pose the question of whose sewage is best. This is definitely a minority viewpoint, however, and the great majority of water consumers take a dim view of deriving all or any small part of their drinking water from the local sewage treatment plant effluent—regardless of the purification processes employed or the quality of the finished product. This feeling arises principally from esthetic considerations but is also supported by questions regarding the safety of the water from a health standpoint. Thus, cities are understandably reluctant to propose recycling of waste waters even under severe emergency conditions and, in some communities, it would not be considered under any circumstances. As a result, there is little or no information available on the operation of water plants utilizing waste waters, and the problems involved have not been studied heretofore under field conditions.

Water Shortage

During the recent drought of 1952–57—the most severe in Kansas history—the city of Chanute was intermittently plagued by water shortages.

Normally, this town of 12,000 persons, which obtains its supply from the Neosho River, uses an average of about 1.4 mgd and a maximum of about 2 mgd. Local industries account for a substantial part of this water use. A program of water conservation reduced water consumption and extended the time during which the available supply could be used. The situation became progressively worse, however, and in the summer of 1956 the Neosho River ceased to flow. Chanute used portable equipment to pump water from upstream pools over riffles to the city's channel storage reservoir above the

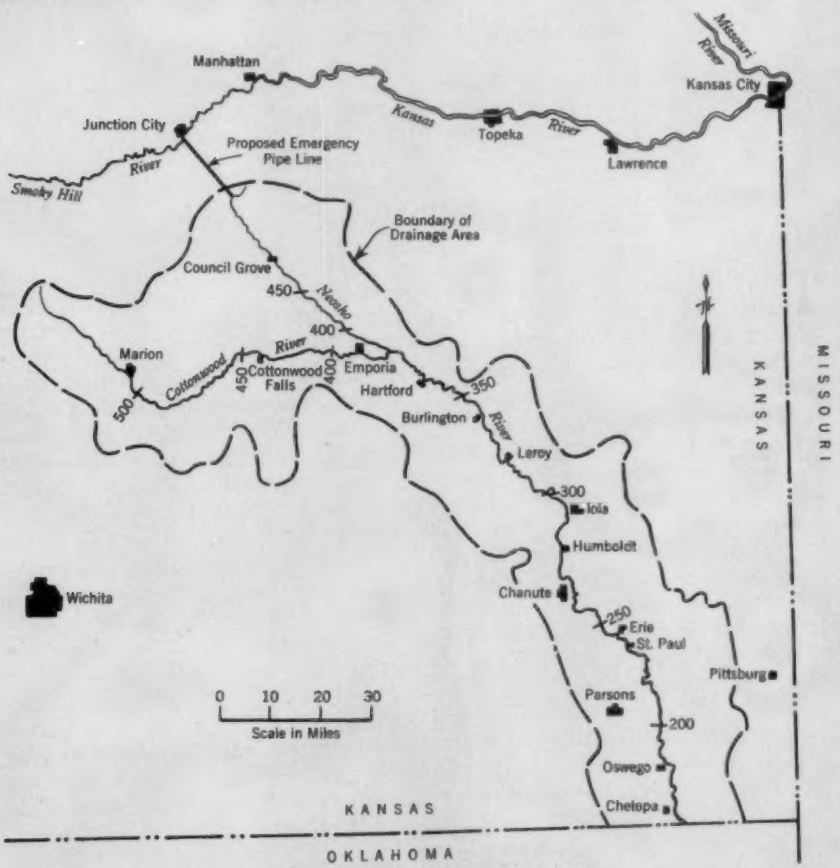

Fig. 1. Neosho River and Vicinity

Proposed emergency pipeline to deliver water from the Smoky Hill River would have included two pump stations. Not shown are two reservoirs from which water could have been released to provide for diversion.

water plant dam. This operation extended upstream about 10 mi to a pool just below the Humboldt, Kan., sewage plant outfall. Figure 1, a map of southeastern Kansas, shows those cities which use the Neosho River as their source of supply. The drainage area above Chanute is approximately 4,000 sq mi.

Solutions Considered

As the drought continued, it became evident that additional action was necessary to supply water to the city. City officials investigated and considered several possible courses. The first was discontinuance of water service to large industrial water users and conservation of the available supply for domestic use. This idea was rejected because it was a very temporary solution at best and meant the loss of livelihood for many Chanute residents as well as substantial direct financial losses by the industries involved—a cement plant, an oil refinery and a wax plant.

Development of a well water supply was an alternative studied extensively prior to and during the drought. In the immediate vicinity of Chanute the yield of wells is meager and the water is highly mineralized. The best source of well water was found to lie in an aquifer of limited area about 4 mi west of the city. Water from this source was not considered suitable as a permanent supply because of its total hardness of 725 mg/l and its sulfate content of 630 mg/l. Development of this source would have involved the drilling and equipping of seven wells to a depth of 150 ft, construction of about 5 mi of pipeline, and the purchase of the necessary rights-of-way. The high cost and temporary nature of this project together with the time required for its completion caused its rejection.

Hauling of potable water by truck or rail was another proposal. The nearest suitable sources were Kansas City and Pittsburg, however, and even at the reduced freight rates which were offered, the cost of hauling was estimated at $4 per 1,000 gal. The number of tank cars required and the logistics of loading, transporting, and unloading also posed some serious problems. The cost and physical limitations of this method caused its rejection.

Joining with other cities located along the Neosho River in a project to pump water from the Smoky Hill River to the upper end of the Neosho was also considered. Some preliminary investigations had been made of a proposal to install two pump stations and about 18 mi of pipeline (Fig. 1) for temporary service in pumping water from the Smoky Hill River near Junction City, Kan., over the divide (static head 400 ft) and into the upper end of the Neosho River. From this point it would flow by gravity to the thirteen cities utilizing the Neosho as a source of supply. Not shown in Fig. 1 are the Cedar Bluff and Kanopolis reservoirs, water from which could be released, if necessary, to supplement the flow of the Smoky Hill River to provide for this diversion. At the time of the water shortage in Chanute, Emporia, Kan., was the only other city interested in this proposal. Even with all thirteen cities (combined population 59,000) participating, the expense of operating such a project would have been high because of the large initial cost and water losses in transit due to seepage and evaporation. If the drought had continued through 1957,

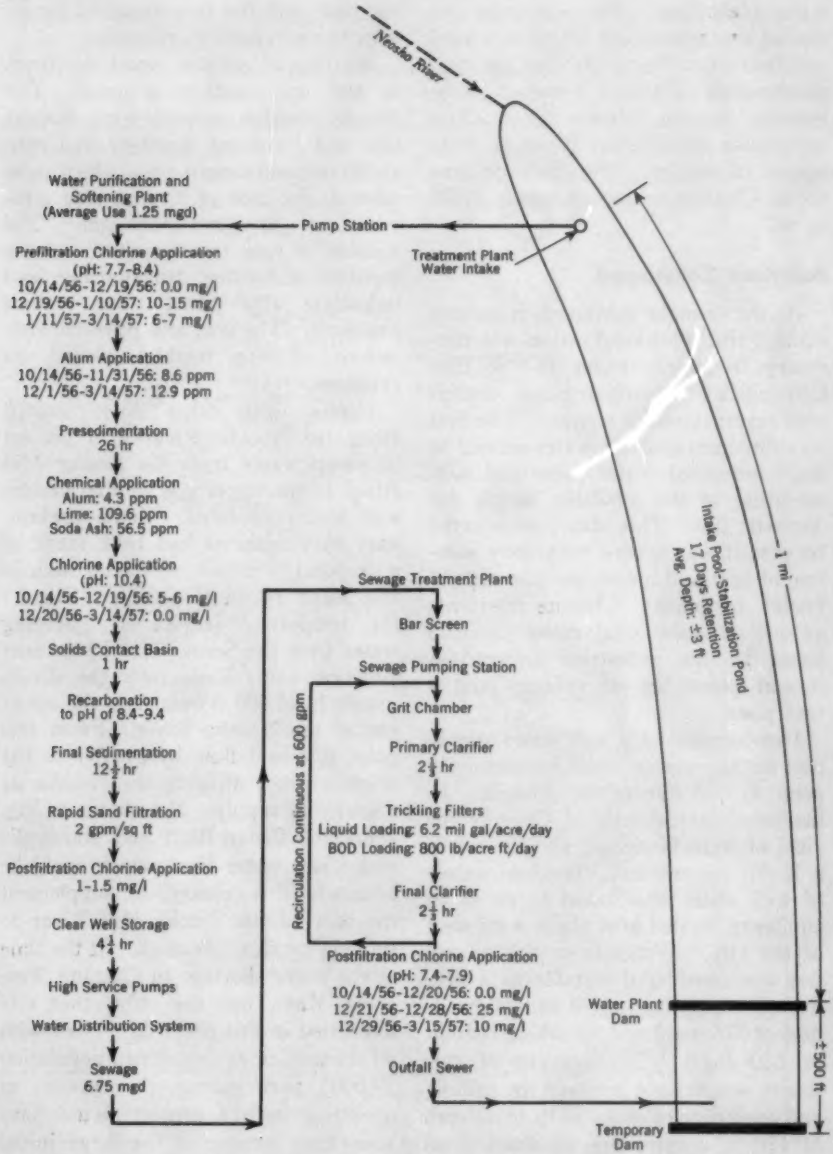

Fig. 2. Flow Diagram of Water Recycling System and Treatment Processes at Chanute

System was that used during 1956–57 period described.

this proposal undoubtedly would have received more serious consideration.

Recirculation of treated sewage was the final proposal and the one which the city officials chose to follow. The effluent of a new secondary sewage treatment plant—completed in 1953—had a concentration of coliform organisms considerably lower than that normally found in the Neosho River at the city's water intake. Much of the river flow past Chanute during the drought was made up of sewage plant effluent from upstream communities, and the city had been using this water for several months without any known ill effects. The relative locations and elevation of the reservoir behind the water plant dam and the outfall sewer were such that the waste water could easily be diverted under controlled conditions to channel storage without pumping. The only construction required was a small earth dam across the river channel below the sewer outfall. Furthermore, this plan could be put into effect almost immediately.

The decision to recirculate treated sewage was made entirely by the city officials. In describing the various means of providing emergency water supply, the authors have attempted to present them as they were viewed by the city officials at the time without implying either concurrence or criticism.

Water and Sewage System

Chanute obtains its water from a Neosho River impoundment formed by a low overflow dam about 1 mi downstream from the water intake. At spillway level, the storage pool is about 200 ft wide and 2 mi long and contains about 60 mil gal.

Under normal operating conditions, raw water is pumped to a plain sedimentation basin of 1.9-mil gal capacity. The settled water, after being treated with alum, lime, soda ash, and chlorine in a solids-contact softening unit of 70,000-gal capacity, flows to a final settling basin of 0.9-mil gal capacity. The influent to this basin is recarbonated by a natural gas–fired underwater burner. Chlorine is added just before and just after rapid sand filtration. There are six filters—each rated at 0.5 mgd at 2 gpm/sq ft. The filters are backwashed by either of two pumps, each having a capacity of 2,600 gpm (15 gpm/sq ft). The finished water is stored in two underground reservoirs with a combined capacity of 247,000 gal and then pumped into the distribution system serving the city. An elevated steel tank provides 250,000 gal storage on the distribution system.

The sewage treatment plant was completed in 1953. Normally, the treatment process employs a bar screen, wet well and pump station, grit chamber, primary clarifier of 160,000-gal capacity, two trickling filters loaded at about 800 lb of BOD per acre-foot per day, a final clarifier holding 160,000 gal, a separate heated sludge digester, and sludge drying beds. Treated sewage can be recirculated from the bottom of the final tank to the wet well where it is mixed with the incoming raw sewage. This is practiced, normally, only during the low-flow period at night.

The outfall sewer from the sewage treatment plant discharges into the Neosho River about 300 ft downstream from the water treatment plant dam.

Recirculation

On Oct. 14, 1956, without fanfare, the city opened the valve which permitted mixing of treated sewage with water stored in the river channel behind the water treatment plant dam,

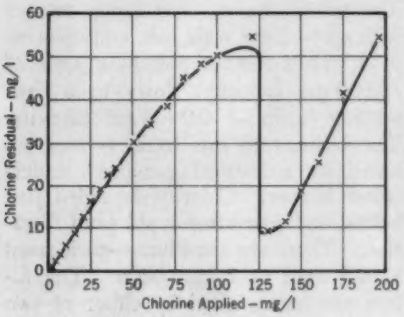

Fig. 3. Residual Chlorination Curve

Curve was plotted for sample collected Feb. 11, 1957.

The recycling process which was thus established is shown in Fig. 2.

By constructing a temporary earth dam across the river channel about 200 ft downstream from the sewer outfall, a body of treated sewage had been formed about 200 ft wide by 500 ft long. The surface elevation of this pool was slightly higher than the water level behind the dam. Existing valves in the dam were available to regulate the flow of water into the water treatment plant intake pool.

When the valve was opened to begin the recycling process, there were approximately 20 mil gal of water in stor-

Fig. 4. Froth on Recarbonation Basin

Froth, produced by agitation of synthetic detergents in the recirculated water, accumulated to a depth of 10–15 ft on still days.

age in the intake pool. This, in effect, added a waste stabilization pond of about 17 days average retention to the treatment process. City water use during the period of recirculation averaged about 1.25 mgd. Restrictions on the use of water for nonconserved air conditioning had been in effect since 1955, and the use of water for car washing and lawn sprinkling had been prohibited for several months. The average daily flow at the sewage treatment plant during the recirculation period was 0.75 mil gal. The total theoretical time for a complete water cycle through the water-softening plant, the sewage treatment plant, and the stabilization pond in the river channel was about 20 days.

From the beginning of recirculation on Oct. 14, 1956, until Dec. 20, 1956, only two changes were made in the treatment processes. At the water plant, 8–13 ppm of alum was added ahead of the presedimentation basin. At the sewage plant, continuous recirculation was practiced by returning 600 gpm from the bottom of the final clarifier to the wet well in order to secure a higher degree of treatment. During this period, the total chlorine dosage at the water plant was 6–7 mg/l. The chlorine was fed ahead of the solids contact basin and just before or just after filtration or both.

On Dec. 14, 1956, through newspaper stories, the fact that reuse of water was being practiced at Chanute came to the attention of the Kansas State Board of Health for the first time. A meeting was held with city officials and it was agreed that additional precautions should be taken. These included the chlorination of the sewage treatment plant effluent, the prechlorination of raw water at the softening plant, and the more frequent collection of raw-water and tap water samples for bacteriological examination.

On Dec. 21, 1956, chlorination equipment was put in operation at the sewage treatment plant. At the start, a dose of 25 mg/l was applied to the plant effluent. After 1 week, the chlorine applied was reduced to 10 mg/l and operation was continued at this level until recirculation was stopped on Mar. 14, 1957.

On Dec. 20, 1956, the first point of chlorination at the water plant was changed from the effluent to the influent of the presedimentation basin to take advantage of the lower pH and longer contact period provided. The chlorine dosage was also increased. From Dec. 20, 1956, to Jan. 10, 1957 about 10–15 mg/l chlorine was applied to the raw water and an additional 1–1.5 mg/l was added in the clear well. On Jan. 11, the prechlorination dose was reduced to 6–7 mg/l with the same rate of postchlorination; this was continued for the duration of the recycling.

Bacteriological sampling was increased from a weekly to a daily schedule. At least one sample of raw water and one sample of tap water were collected each day.

Operating Experience

Aside from the additional operating chores which were involved in chlorinating the plant effluent and continuously recirculating within the plant to secure more complete treatment, there were no appreciable effects on operation of the sewage treatment plant. There was an unprecedented awareness on the part of local residents and their neighbors in nearby communities of the innovation at Chanute and spectators

TABLE 1

Data on Collection, Preservation and Transportation of Samples During Reuse of Water at Chanute, Kan.—1957

Analysis or Examination	Sample*			Type and Amount of Preservative	Transportation Time—*hr*
	Origin†	Volume *ml*	Container		
Chemical and physical	RW	4,000	polyethylene	none	4
	TW	4,000	polyethylene	none	4
	RS	4,000	polyethylene	none	4
	TS	4,000	polyethylene	none	4
Coliform organism	RW	500	glass	0.05 g $Na_2S_2O_3 \cdot 5H_2O$	4
	SW	500	glass	0.05 g $Na_2S_2O_3 \cdot 5H_2O$	4
	TW	500	glass	0.05 g $Na_2S_2O_3 \cdot 5H_2O$	4
Virus	RW	4,000	glass	0.4 g $Na_2S_2O_3 \cdot 5H_2O + 5 \times 10^5$ units penicillin + 1 g dihydrostreptomycin§	24‖
	TW	4,000	glass	0.4 g $Na_2S_2O_3 \cdot 5H_2O + 5 \times 10^5$ units penicillin + 1 g dihydrostreptomycin	24‖
	RS	500	glass	0.05 g $Na_2S_2O_3 \cdot 5H_2O + 6.2 \times 10^4$ units penicillin + 125 mg dihydrostreptomycin	24‖
	TS	4,000	glass	0.4 g $Na_2S_2O_3 \cdot 5H_2O + 5 \times 10^5$ units pencillin + 1 g dihydrostreptomycin	24‖
Zoological organisms	RW	4,000	glass	0.5 g $Na_2S_2O_3 \cdot 5H_2O$	24‖
	TW	4,000	glass	0.5 g $Na_2S_2O_3 \cdot 5H_2O$	24‖
	TS	4,000	glass	0.5 g $Na_2S_2O_3 \cdot 5H_2O$	24‖
Plankton	RW	2,000	polyethylene	50 ml commercial formalin	168±
	SW	2,000	polyethylene	50 ml commercial formalin	168±
	TW	2,000	polyethylene	50 ml commercial formalin	168±
	TS	2,000	polyethylene	50 ml commercial formalin	168±
Spectrographic and cation	RW	4,000	polyethylene	none	24‖
	TW	4,000	polyethylene	none	24‖
Coliform organism	RW	—	ointment tins	inhibiting medium	48±
	TW	—	ointment tins	inhibiting medium	48±

* All samples except those of the plankton were iced. Chemical, physical, aud coliform analyses were conducted by the State Board of Health laboratory, Lawrence, Kan.; all others at Robert A. Taft Sanitary Engineering Center, Cincinnati.

† Key: RW, raw water; SW, settled water; TW, tap water; RS, raw sewage; TS, treated but unchlorinated sewage.

‡ Beginning Mar. 5, additional samples were collected by filtering 5 gal through several Type SS 0.047-mm membrane filters which were then placed in 50 ml of distilled water.

§ Penicillin and dihydrostreptomycin was freshly prepared and added to samples immediately after collection.

‖ Samples taken Jan. 22 and Feb. 4 were delayed an additional 24 hr.

from near and far visited the plant to observe its operation.

During the period of water reuse, the sewage treatment plant removed, on the average, 86 per cent of the BOD and 76 per cent of the chemical oxygen demand. It provided substantial reduction in both total and ammonia nitrogen concentrations. Sewage treatment also reduced alkyl benzene sulfonate (ABS) an average of 25 per cent and complex phosphates by 67 per cent.

The impounding reservoir served very effectively as a waste stabilization pond. It reduced the applied BOD and chemical oxygen demand loading by approximately 75 per cent; the total and ammonia nitrogen concentrations by more than 55 per cent; and the ABS by more than 50 per cent.

Operating difficulties at the water plant were perhaps less serious than might have been expected under the circumstances. The high ammonia content of the raw water made free residual chlorination impractical for taste and odor control and complete color removal. Figure 3 shows the chlorine demand curve of a raw-water sample with a good breakpoint at a chlorine dosage of 130 mg/l. The break occurred at the expected figure of about ten times the ammonia concentration.

Froth was a nuisance in the operation of the plant and, on occasion, provided a spectacular display for passersby on the highway adjacent to the water plant. Most of the froth was produced by agitation of water in the recarbonation basin. On still days the froth would accumulate to a depth of 10–15 ft, completely covering and hiding the small building which housed the carbon dioxide compressor (Fig. 4). On windy days, large clouds of froth would be wafted into the air and carried downwind. This frothing was due principally to the high concentration of synthetic detergents in the recirculated water.

Coagulation and settling were less effective than under normal circumstances. Although there was considerable carry-over of floc particles onto the filters, there was no evidence of rising floc such as occurred at Osawatomie, Kan. (*2*), when detergent concentrations were high.

The most serious trouble occurred in operation of the rapid sand filters. This can be attributed partly to the character of the applied water although defects in the filters aggravated the situation. The capacity of the wash water sewer was barely sufficient to carry away the flow usually required for backwashing. The influent valves leaked and allowed settled water to enter the filters at a rapid rate during backwashing. This made it necessary to reduce the rate of backwash to avoid exceeding the wash water sewer capacity.

Deposits were observed on the sand grains and the size of the grains increased rapidly. About 3 months after recirculation started, it was necessary to clean the filter sand manually. Each filter was taken out of service and the sand removed and cleaned by agitation in a concrete mixer while applying liberal quantities of water. At the same time, the filter influent valves were removed and repaired. After the sand was replaced in the filters, each unit was backwashed 15–20 times. Considerable frothing occurred and additional quantities of foreign material were removed from the beds. No detailed analyses were made of the coating on

the sand grains but, because of its solubility in hydrochloric acid, it was believed to be largely calcium carbonate. The frothing which occurred during backwashing suggested that synthetic detergents or other surface-active substances were also present. The sand had a strong fishy odor similar to that of decomposing algae or other organic material.

Determinations at the plant laboratory gave false evidence of free-chlorine residuals by the orthotolidine-arsenite (OTA) procedure. The flash colorimetric method also gave erroneous readings of 2.0 mg/l of free residual chlorine in the presence of 1.6–12.0 mg/l ammonia nitrogen in the tap water. Amperometric titration showed no evidence of free chlorine. The total

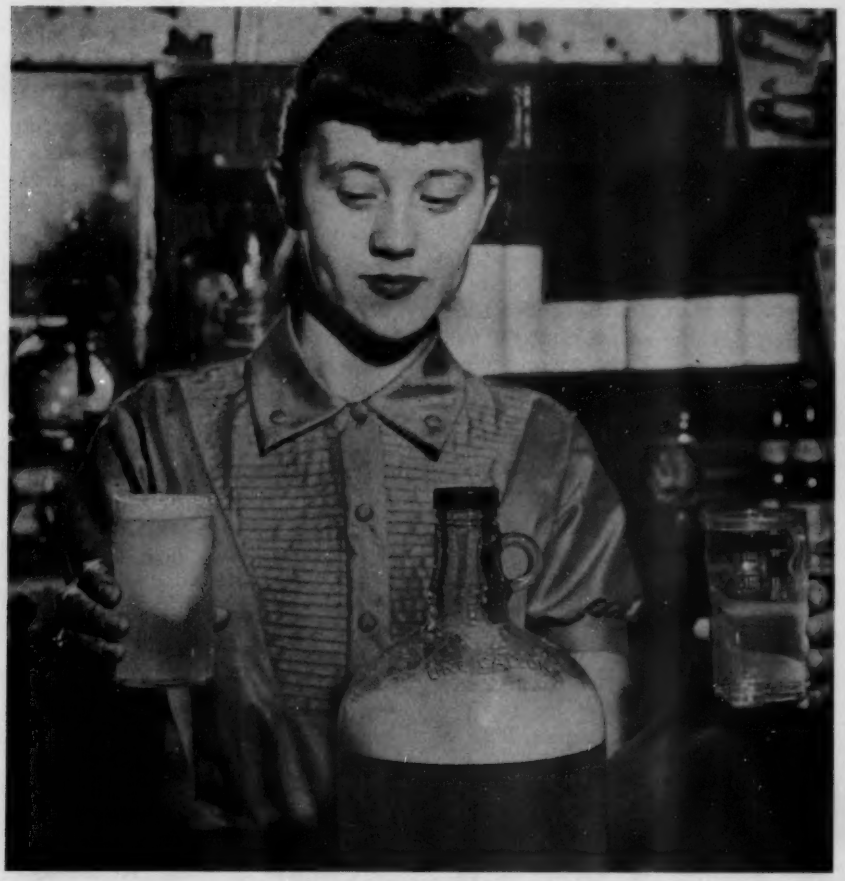

Fig. 5. Suds in Chanute Tap Water

Clear water in glass at right is tap water from Parsons, Kan.

combined chlorine residual as measured by amperometric titration averaged about 5.0 mg/l at the plant tap during water reuse. The use of the color comparator was discontinued and all chlorine residual measurements were made amperometrically. To supplement frequent laboratory tests, a continuous chlorine residual recorder was installed on a plant tap.

The treated water had several objectionable characteristics. It had a pale yellow color and an unpleasant musty taste and odor. The tap water was high in chlorides, total solids, and organic content—adding to the taste and odor problem. Agitation of the water —as in drawing a glass of it from the tap—caused frothing because of the high ABS content (Fig. 5). The frothing of the tap water served as a constant unpleasant reminder of the source of the city's water supply. The cooling tower at the municipal power plant caused considerable comment because of the constant "snow storm" of froth produced by it.

The water was unsuitable for most laboratory purposes. Even after double distillation it could not be used for making standard solutions or mixing reagents because of carry-over.

Water Quality Studies

Following preliminary discussions by telephone and letter, a conference was held at Lawrence, Kan., on Jan. 3, 1957, by the Kansas state board of health and USPHS representatives to plan an intensive study of the reuse of water at Chanute.

Arrangements were made for the collection and shipment of samples—beginning Jan. 15, 1957—and for various analyses to be performed at the water and sewage laboratory in Lawrence and at the sanitary engineering center in Cincinnati. One regular point each was selected for the collection of grab samples of raw water, treated water, raw sewage, and treated sewage prior to chlorination. Additional sampling points were to be utilized as indicated by developments during the course of the work. It was agreed that reasonably representative samples of sewage plant effluent could be obtained at 10–11 AM, which time was also convenient for the immediate shipment of samples.

In general, the water and sewage laboratory was to make the physical and chemical analyses and the bacteriological examinations by standard dilution techniques and the immediate membrane filter method. The sanitary engineering center was to make special chemical tests and examine samples for zoological organisms, viruses, and plankton—as well as for coliform organisms—by the delayed membrane filter procedure where applicable *Standard Methods* (*3*) procedures were used.

Information on the collection, preservation, and transportation of samples is given in Table 1, on page 1028. All samples were collected by the district sanitarian or other department of health personnel.

Chlorides

Chloride concentrations and the relationships between rainfall, stream flow, and water level fluctuations in the intake pool during the reuse of water are given in Fig. 6. The actual period of recirculation extended from Oct. 14, 1956, to Mar. 14, 1957. Information over a longer period is given in order to include the transition periods at the start and finish and to furnish a basis for comparison with normal conditions.

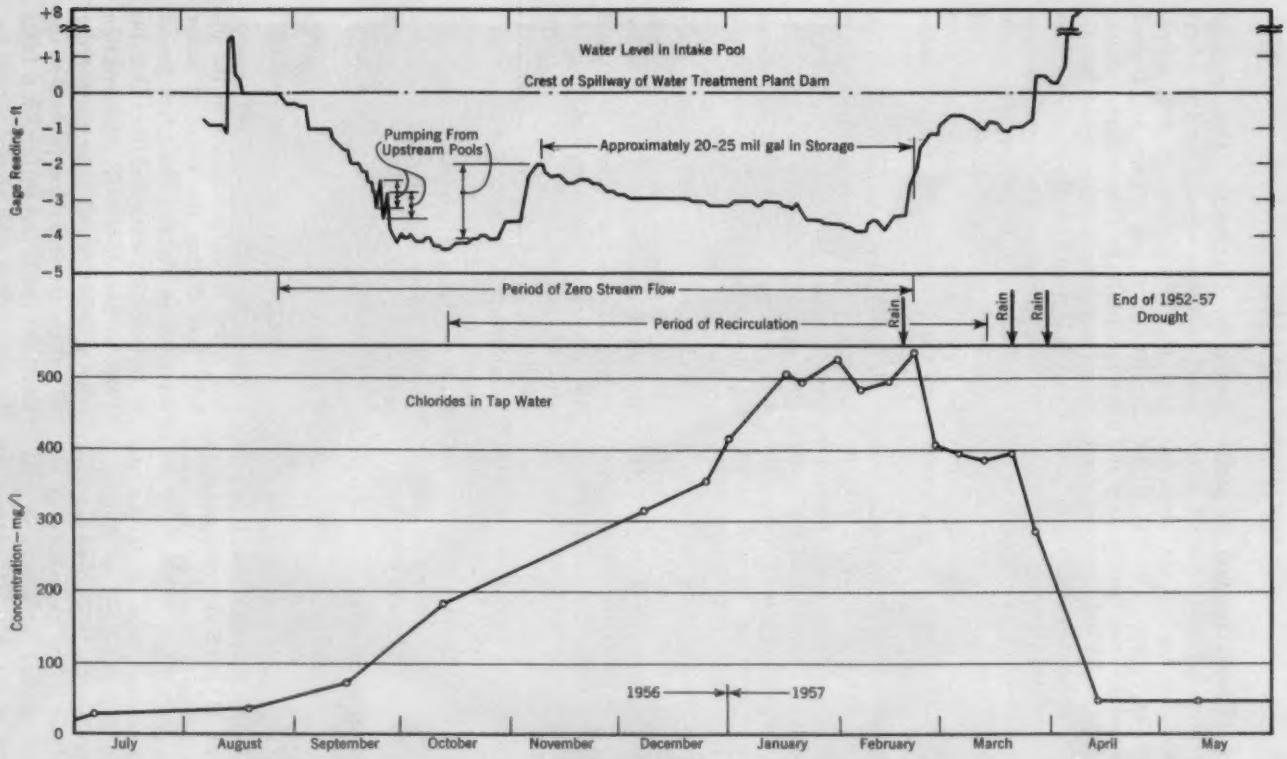

Fig. 6. Tap Water Chloride Concentration and Water Level in Intake Pool

Although actual recirculation was practiced from Oct. 14, 1956, to Mar. 14, 1957, a longer period is shown in order to include transition periods and provide comparison with normal conditions.

There was no measurable flow in the Neosho River from Aug. 29, 1956, through Feb. 15, 1957. The gage readings show the effects of pumping water over riffles from upstream pools in late September, October, and early November 1956. From early November until the middle of February 1957, the amount of water in storage in the water plant intake pool remained fairly constant at 20–25 mil gal. The only losses were from evaporation, seepage, and consumptive water use. On Feb. 15, 1957, light rains which occurred on the watershed above Chanute brought in in some fresh water although the water level remained below the spillway and recirculation was continued until Mar. 14. Further rains on Mar. 21 put water over the spillway. Heavy general precipitation on Mar. 31 produced an additional rise of 8 ft and ended the 5-year drought.

With cessation of stream flow in August, there was an almost immediate increase in chloride content from the normal of about 40 mg/l. By the time recirculation was started in October, the chlorides had increased to about 180 mg/l. The buildup continued steadily to values of 400–500 mg/l during January and February. Light rains provided sufficient dilution to reduce the concentration to about 400 mg/l during March. Following the heavy spring rains, the chlorides dropped abruptly to normal concentrations.

Domestic and other municipal uses of water result in increased concentrations of chlorides. Studies reported by the California State Water Pollution Control Board (*4*) indicate this increase in chlorides from tap water to sewage to be about 20–50 mg/l. Table 2 shows chloride data obtained in the Chanute study. Results of 15 analyses

TABLE 2

Chloride Concentrations During Water Reuse at Chanute

Date* 1957	Concentrations—mg/l				
	Raw Water	Tap Water	Increment (Tap Water to Raw Sewage)	Raw Sewage	Treated Sewage
Jan. 15	510	510	+20	530	530
Jan. 22	460	500	+20	520	520
Jan. 28	530	520	+20	540	540
Jan. 30	530	540	+30	570	560
Feb. 4	510	520	+30	550	510
Feb. 6	500	500	0	520	460
Feb. 11	480	470	+50	520	470
Feb. 13	500	500	+20	520	500
Feb. 19	570	520	+20	540	520
Feb. 20	670	550	+10	560	530
Feb. 26	400	480	+40	520	510
Mar. 5	380	400	+70	470	450
Mar. 12	390	390	+50	440	430
Mar. 19	360	390	+80	470	400
Mar. 26	360	380	+10	390	340
Average	477	479	+32	511	485

* Figures after and including those for Feb. 19 are for period after resumption of flow of Neosho River.

TABLE 3

*Total Nitrogen, Ammonia Nitrogen, Nitrite Nitrogen, and Nitrate Nitrogen Concentrations During Water Reuse at Chanute**

Date* 1957	Concentrations—*mg/l*															
	Total Nitrogen				Ammonia Nitrogen				Nitrite Nitrogen				Nitrate Nitrogen			
	Water		Sewage		Water		Sewage		Water		Sewage		Water		Sewage	
	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated
Jan. 15					8.4	7.3	35	31	0.09	0.05	0.29	0.17	0.6	0.6	0.4	1.7
Jan. 22	10.0	11.0	70	33	8.4	9.7	46	26	0.08	0.05	0.15	0.24	0.7	0.8	0.3	1.6
Jan. 28	14.0	12.0	64	34	12.0	10.0	42	27	0.12	0.06	0.26	0.20	0.9	1.0	0.5	1.6
Jan. 30	13.0	12.0	56	33	11.0	10.0	40	27	0.11	0.05	0.14	0.15	0.4	0.4	0.4	1.0
Feb. 4	16.0	14.0	82	33	13.0	12.0	53	28	0.11	0.06	0.17	0.17	0.4	0.5	0.6	1.2
Feb. 6	16.0	14.0	74	33	14.0	11.0	46	26	0.09	0.03	0.17	0.17	0.4	0.8	0.5	0.5
Feb. 11	17.0	16.0	96	37	13.0	12.0	57	30	0.10	0.05	0.28	0.22	0.2	0.3	0.4	0.4
Feb. 13	17.0	15.0	95	38	13.0	10.0	57	36	0.10	0.05	0.24	0.22	0.5	0.2	0.3	1.0
Feb. 19	7.8	14.0	95	39	4.8	12.0	52	32	0.05	0.03	0.22	0.21	0.1	0.4	0.6	0.8
Feb. 20	1.3	11.7	92	33	0.3	9.5	57	25	0.01	0.04	0.30	0.19	<0.01	0.2	0.5	0.6
Feb. 26	4.6	1.9	77	27	3.4	1.6	47	20	0.04	0.02	0.07	0.19	0.1	0.04	0.2	0.3
Mar. 5	6.0	5.4	78	31	3.4	4.7	46	24	0.08	0.04	0.11	0.19	0.1	0.2	0.1	0.3
Mar. 12	5.3	4.9	84	33	3.8	3.8	49	23	0.06	0.02	0.07	0.27	0.1	0.2	0.2	0.9
Mar. 19	4.8	3.6	73	23	3.0	2.7	44	17	0.08	0.02	0.00	0.36	0.3	0.2	0.6	2.5
Mar. 26	3.5	2.8	61	22	2.5	2.0	34	16	0.07	0.02	0.13	0.33	0.3	0.3	0.8	2.8

* Figures after and including those for Feb. 19 are for period after resumption of flow of Neosho River.

TABLE 4

Alkyl Benzene Sulfonate and Phosphate Concentrations During Water Reuse at Chanute

Date* 1957	ABS—mg/l				Orthophosphate—mg/l				Total Phosphate—mg/l			
	Water		Sewage		Water		Sewage		Water		Sewage	
	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated
Jan. 15	3.6	3.5	15.0	9.1	11.4	2.6	27.5	24.5	13.4	3.2	41.5	32.0
Jan. 22	3.5	4.2	12.0	11.0	10.4	3.4	22.0	31.0	11.4	3.6	34.5	36.5
Jan. 28	4.1	4.0	11.0	10.0	11.8	3.6	19.5	17.0	13.4	4.1	35.0	25.0
Jan. 30	4.1	4.1	11.0	10.0	10.0	3.8	22.0	21.5	12.0	4.2	30.0	30.0
Feb. 4	5.3	5.1	16.0	10.0	11.6	3.0	19.0	15.0	13.0	3.7	42.0	22.5
Feb. 6	5.8	4.6	13.0	10.0	11.8	3.3	17.0	15.5	13.4	3.8	32.5	22.5
Feb. 11	5.1	4.8	17.0	10.0	12.8	3.0	25.5	23.5	14.6	3.4	66.0	28.0
Feb. 13	5.7	5.1	14.0	13.0	13.6	4.6	25.5	28.5	15.0	5.0	46.0	34.5
Feb. 19	2.3	4.7	13.0	11.0	5.4	2.4	16.5	26.0	6.8	2.6	35.0	30.5
Feb. 20	0.4	3.9	12.0	10.0	0.4	2.1	23.5	19.5	0.8	2.3	43.0	25.0
Feb. 26	1.6	0.9	8.3	7.8	3.1	0.4	18.5	23.5	3.5	0.5	31.5	27.0
Mar. 5	1.8	1.9	13.0	8.8	4.5	1.2	22.0	29.5	4.6	1.1	51.5	32.5
Mar. 12	1.8	1.7	17.0	9.1	4.1	2.8	18.5	24.5	4.5	2.9	59.0	28.5
Mar. 19	1.6	1.5	16.0	8.3	3.3	0.6	18.5	24.5	3.4	0.6	52.0	26.5
Mar. 26	1.4	1.4	18.0	7.2	2.5	0.7	13.0	17.0	2.7	0.7	49.0	20.0

* Figures after and including those for Feb. 19 are for period after resumption of flow of Neosho River.

TABLE 5

Chemical and Biochemical Oxygen Demands During Water Reuse at Chanute

Date*	BOD—mg/l				Chemical Oxygen Demand—mg/l			
	Water		Sewage		Water		Sewage	
	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated
Jan. 15	4.6		180	47	44	36	540	160
Jan. 22	5.1		220	31	45	42	570	180
Jan. 28	4.7		190	31	58	44	570	160
Jan. 30	5.3		130	32	54	41	440	160
Feb. 4	7.2		240	24	59	45	700	130
Feb. 6	7.2		200	18	58	42	610	160
Feb. 11	11.0		275	22	63	44	1080	140
Feb. 13	13.0		235	28	71	52	740	160
Feb. 19	9.5		260	30	28	46	780	150
Feb. 20	6.2		240	28	28	43	730	150
Feb. 26	6.8		220	27	32	16	730	130
Mar. 5	7.8		250	35	36	24	800	140
Mar. 12	6.5		320	35	36	28	950	140
Mar. 19	5.8		280	19	35	24	850	120
Mar. 26					32	20	860	120

* Figures after and including those for Feb. 19 are for period after resumption of flow of Neosho River.

of tap water and raw sewage show an apparent average increment of 32 mg/l. This apparent increase may be higher than the true value; however, the test results show an average chloride concentration—in the raw and treated sewages—of 511 and 485 mg/l respectively. There is no reason to believe that chlorides were removed in sewage treatment. This indicated reduction

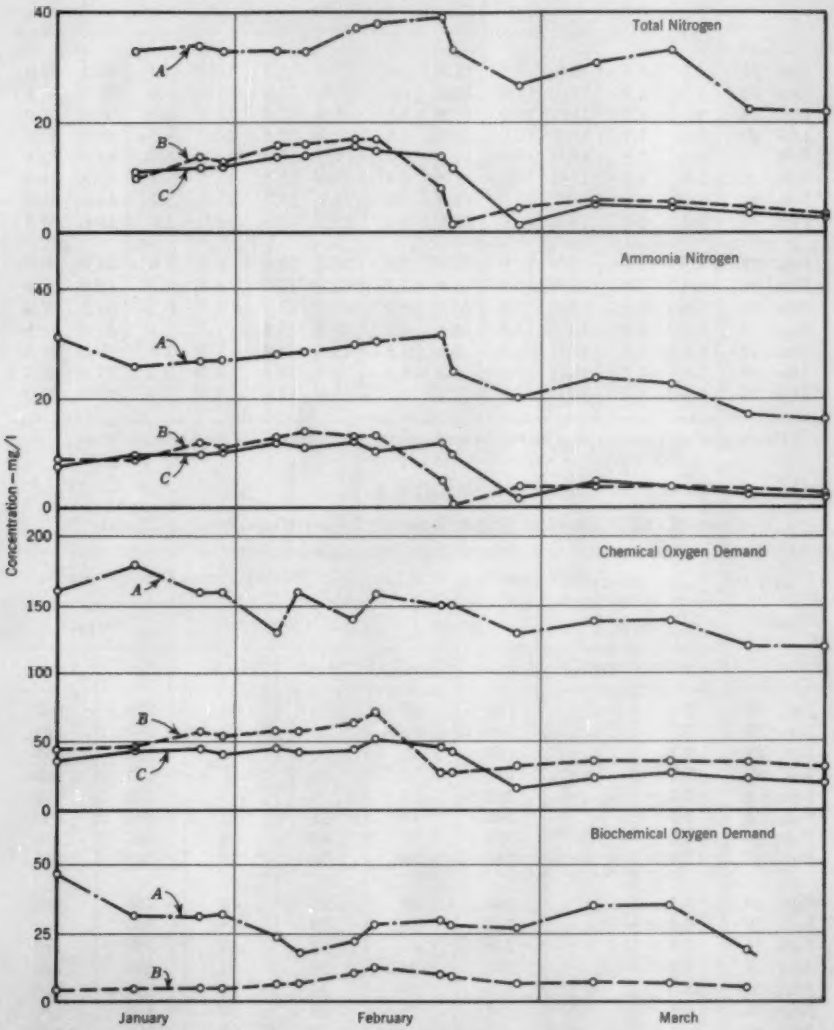

Fig. 7. Oxygen Demand and Nitrogen Concentrations

Curves labeled A *are for treated sewage;* B, *for raw water; and* C, *for tap water.*

in chlorides probably resulted from the use of grab samples which did not represent the same sewage before and after treatment.

The chloride increase during the recirculation period indicates that the water was reused about ten times. Other methods of estimating the number of cycles show reuse of from eight to fifteen times.

Interpretation of the chloride data is complicated by the unknown quantities of highly mineralized oil field brines which entered the river in the vicinity of the water plant for at least a part of the time that recirculation was practiced.

Ponds and transmission ditches used for water flooding of oil formations in the immediate area permitted seepage of the brine downward to a thin alluvium which was intersected by the river channel. Faulty maintenance of these facilities caused some accidents which contributed significant amounts of brine to the supply.

Pollution

Factors which indicate the buildup of pollution in the raw water are data on nitrogen in its various forms, BOD, chemical oxygen demand, ABS, and total phosphates and orthophosphates. The detailed laboratory results are presented in Tables 3, 4, and 5. The pollution load resulting from recycling of water was already substantial at the time of the first sampling on Jan. 15. Thereafter, as illustrated by Fig. 7 and 8, the concentrations of total and ammonia nitrogens, BOD, and ABS continued to increase until February rains provided some dilution. At the peak, the raw water contained 17 mg/l nitrogen, 5.8 mg/l ABS, and had a BOD of 13 mg/l.

TABLE 6

Averaged Results With Selected Pollution Indicators for Period Jan. 15–Feb. 13, 1957

Indicator	Raw Sewage *mg/l*	Treated Sewage *mg/l*	Reduction in Sewage Treatment *per cent*	Raw Water *mg/l*	Treated Water *mg/l*	Overall Reduction (Raw Sewage to Treated Water) *per cent*
Nitrogen (total)	78	34	56	15	13	83
Nitrogen (NH_3)	47	29	38	12	10	79
Chemical Oxygen Demand	656	156	76	56	43	93
BOD	209	29	86	7.3		
ABS	13.6	10.4	25	4.6	4.4	68
Orthophosphate*	22	22	0	12	3.4	88
Phosphate (total)*	41	29	29	13	3.9	95
Phosphate (complex)*	19	7	67	1	0.5	97

* As PO_4.

Table 6 shows the efficiency of sewage treatment and the overall treatment process in reducing the concentration of the selected pollution indicators during the period of maximum concentrations of these substances. The complex phosphates were the most completely removed—97 per cent—and the ABS was the most persistent, with only 68 per cent removed.

The remarkable effectiveness of the raw-water impoundment in reducing concentrations of these various substances is apparent. It is particularly

striking for the total nitrogen and ammonia. There is no clear evidence as to the mechanism by which the ammonia was removed, but it is clear that the 2–3 weeks' storage in this shallow impoundment resulted in major improvement in water quality. It is doubtful if recirculation could otherwise have continued as long as it did.

The average increase in ABS concentration from treated water to raw sewage was 10.4 mg/l, and the average increase in phosphate concentration was 40.4 mg/l—of which 18.2 mg/l was orthophosphate and the remainder complex phosphates. A major part of the phosphate increment is due to synthetic detergents. Before their use,

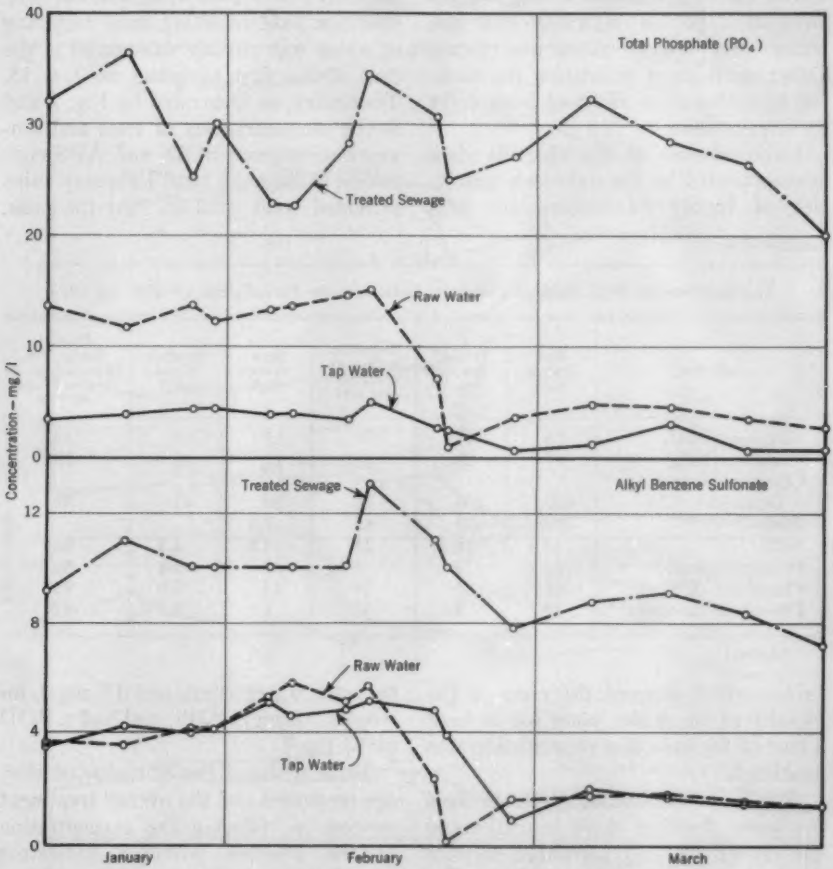

Fig. 8. Phosphate and ABS Concentrations

ABS concentrations were determined with three different procedures—the methylene blue method, the methyl green, and the extraction-infrared technique.

sewage normally contained about 5 mg/l phosphorus as PO_4. Phosphates were effectively removed in the water treatment plant, undoubtedly in the softening process. The water treatment plant was not very effective in removing ABS, chemical oxygen demand, or various forms of nitrogen.

Figure 7 is a graphical presentation of the total and ammonia nitrogen, BOD, and chemical oxygen demand in treated sewage, raw water, and tap

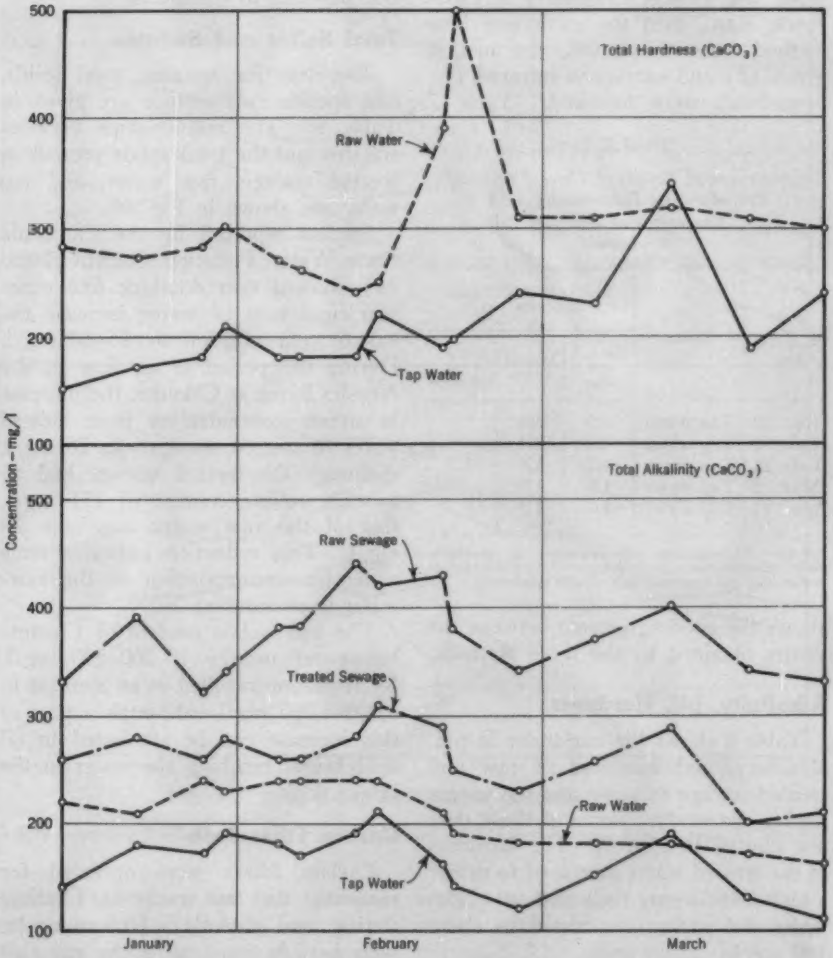

Fig. 9. Hardness and Alkalinity Concentrations

Figure uses alkalinity and hardness data shown in Table 8.

water. Figure 8 shows the variations, during the period of study, in ABS and total phosphates, in treated sewage and raw and tap waters.

In determining the concentration of ABS in water samples, three different analytical procedures were used. The water and sewage laboratory at Lawrence, Kan., used the methylene blue method. At Cincinnati, the methyl green (*5*) and extraction-infrared (*6*) procedures were followed. Table 7 shows the good agreement between the values obtained by the three methods.

TABLE 7

Comparison of Results of Three Analytical Procedures for Determining ABS Concentration in Water at Chanute

Date of Sampling 1957	Source	Results With Different Procedures—mg/l		
		Methylene Blue	Methyl Green	Extraction-Infrared*
Jan. 22	Raw water	3.5	3.6	
Jan. 22	Tap water	4.2	4.4	
Feb. 21	Tap water	4.7	4.9	3.5
Mar. 5	Tap water	1.9	1.9	
Mar. 12	Tap water	1.7	1.5	

* The extraction-infrared procedure is currently under investigation. It is considered that the sample has at least the concentration of ABS measured.

Alkalinity, pH, Hardness

Table 8 shows the variations in pH, alkalinity, and hardness of raw and treated sewage and raw and tap waters during the study. Some of these data are plotted in Fig. 9. The hardness of the treated water increased to rather a high level during recirculation. Normally the water is softened to about 100 mg/l.

A comparison of the effectiveness of lime and soda ash in reducing hardness during the recirculating period and during periods of normal operation shows that, at the dosages used, both of these softening chemicals were fully effective. The plant operators reported that increased doses of softening chemicals resulted in the carry-over of more floc particles to the filters.

Total Solids and Sulfates

The data for sulfates, total solids, and specific conductance are given in Table 9. The relationships between sulfates and the total solids present in treated sewage, raw water, and tap water are shown in Fig. 10.

Studies reported by the California State Water Pollution Control Board (*4*) showed that domestic and other municipal uses of water increase the sulfate concentration by 15–30 mg/l. During the period of no flow in the Neosho River at Chanute, the increase in sulfate concentration from treated water to treated sewage was 26 mg/l. Although the treated sewage had an average sulfate content of 111 mg/l, that of the raw water was only 79 mg/l. This reduction indicates some anaerobic decomposition in the raw-water impoundment.

The total-solids content of Chanute tap water usually is 200–500 mg/l. Recirculation resulted in an increase to 1,000–1,200 mg/l—although a part of this increase can be attributed to oil field brines reaching the water in the intake pool.

Carbon Filter Tests

Carbon filters were operated for sampling the tap water at Chanute during two periods. Unfortunately, both periods came after the rains of Feb. 15 had brought some improvement in water quality. As a result, no

data are available on the content of extractable organic material in the water during the period of heaviest contamination. This carbon filter technique has been described in the JOURNAL (*7, 8*). Table 10 shows the results obtained on the two Chanute samples and typical results from three other waters for purposes of comparison. The Columbia River at Bonneville Dam is relatively free of pollution, and the total extractable organic load is only 120 μg/l. At Wyandotte, Mich., the Detroit River is affected by much of the industrial and other wastes from the Detroit area and, in spite of the large flow, the extractable organics amount to 465 μg/l, of which somewhat less than half is in the chloroform extract. The Merrimack River at Lawrence, Mass., is affected by considerable municipal and industrial

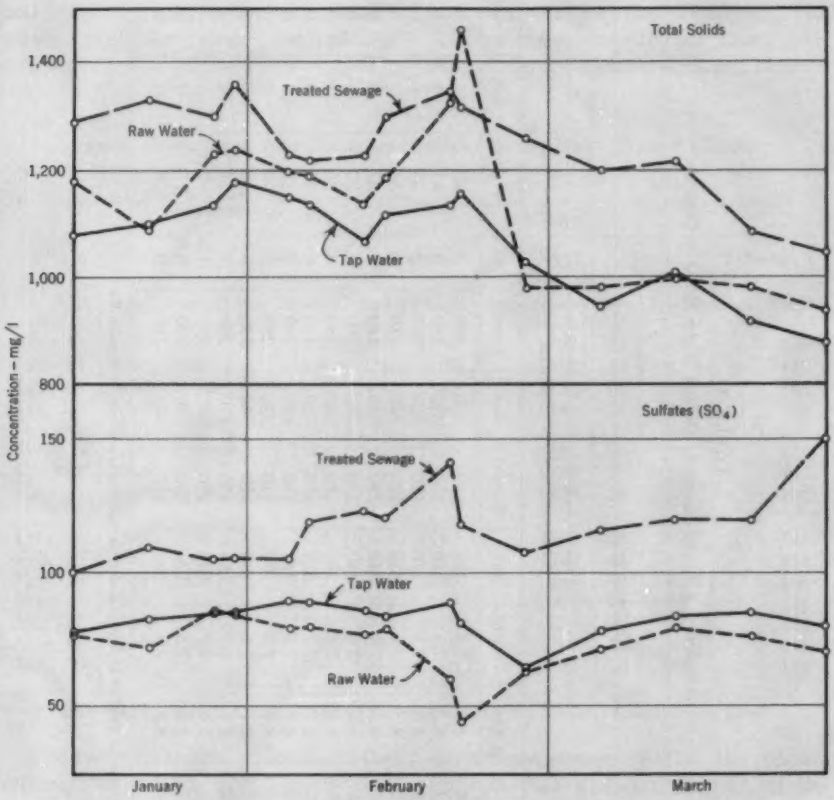

Fig. 10. Total-Solids and Sulfate Concentrations

Treated sewage had an average sulfate content of 111 mg/l; raw water only 79 mg/l.

TABLE 8

Alkalinity, pH, and Hardness During Water Reuse at Chanute

Date* 1957	pH				Alkalinity—*mg/l* $CaCO_3$								Hardness *mg/l* $CaCO_3$	
	Water		Sewage		Total				Phenolphthalein					
					Water		Sewage		Water		Sewage		Water	
	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated
Jan. 15	8.2	9.4	8.5	7.8	220	140	330	260	0	40	18	0	280	150
Jan. 22	8.0	9.2	8.3	7.4	210	180	390	280	0	45	34	0	270	170
Jan. 28	7.7	8.8	8.0	7.5	240	170	320	260	0	38	0	0	280	180
Jan. 30	7.9	8.9	8.3	7.8	230	190	340	280	0	34	8	0	300	210
Feb. 4	8.0	8.9	8.3	7.7	240	180	380	260	0	27	0	0	270	180
Feb. 6	7.9	8.6	8.4	7.6	240	170	380	260	0	20	16	0	260	180
Feb. 11	8.1	8.8	8.3	7.6	240	190	440	280	0	30	Tr	0	240	180
Feb. 13	8.1	8.4	8.1	7.7	240	210	420	310	0	20	0	0	250	220
Feb. 19	8.2	9.0	8.7	7.7	210	160	430	290	0	30	42	0	390	190
Feb. 20	8.2	9.0	8.1	7.9	190	140	380	250	0	28	0	0	500	220
Feb. 26	8.1	8.7	8.1	7.6	180	120	340	230	0	14	0	0	310	240
Mar. 5	8.4	8.9	8.1	7.7	180	150	370	260	5	21	0	0	310	230
Mar. 12	8.4	8.4	7.9	7.7	180	190	400	290	7.0	7.0	—	—	320	340
Mar. 19	8.4	8.7	7.9	7.6	170	130	340	200	6.0	15	0	0	310	190
Mar. 26	8.2	8.9	8.2	7.8	160	110	330	210	0	20	0	0	300	240

* Figures after and including those for Feb. 19 are for period after resumption of flow of Neosho River.

waste and shows 743 μg/l of extractable organics with about the same proportion of chloroform and alcohol extract as at Wyandotte.

As a rule, it has been found that the chloroform-extractable fraction contains the most highly odorous materials and is more characteristic of industrial waste pollution than the alcohol extract.

rains of Feb. 15. The concentration of extractable organics in these samples was probably below the peak concentration in about the same proportion.

The alcohol extract from the first of the Chanute samples was assayed for detergents, using extraction and infrared methods for identification. The ABS content was 28 per cent. Although the procedure does not recover

TABLE 9

Specific Conductance, Total Solids, and Sulfates During Water Reuse at Chanute

Date* 1957	Specific Conductance *micromhos/cm*				Total Solids—*mg/l*				Sulfates—*mg/l* SO_4			
	Water		Sewage		Water		Sewage		Water		Sewage	
	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated
Jan. 15	2120	1990		2380	1180	1080		1290	77	78		100
Jan. 22	2120	1990		2380	1090	1100		1330	72	83		110
Jan. 28	2280	2100		2410	1230	1140		1300	85	85		105
Jan. 30	2350	2250		2660	1240	1180		1360	84	85		105
Feb. 4	2140	2010		2230	1200	1150		1230	79	90		105
Feb. 6	2260	2250		2320	1190	1140		1220	80	89		119
Feb. 11	2060	1930		2240	1140	1070		1230	77	86		123
Feb. 13	2360	2210		2660	1190	1120		1300	79	84		121
Feb. 19	2310	2130		2550	1330	1140		1350	60	89		141
Feb. 20	2630	2240		2580	1460	1160		1320	44	81		118
Feb. 26	1680	1810		2220	980	1030		1260	62	64		108
Mar. 5	1770	1770		2300	980	950		1200	71	78		116
Mar. 12	1750	1780		2240	1000	1010		1220	79	83		121
Mar. 19	1730	1700		2050	980	920		1090	76	85		120
Mar. 26	1520	1460		1730	940	880		1050	70	80		150

* Figures after and including those for Feb. 19 are for period after resumption of flow of Neosho River.

The two Chanute samples show that although the extractable organic load was quite high, it was not inordinately higher than at Lawrence, Mass.—with about five-sixths of the load in the alcohol extract. During the period when these two samples were collected, the concentration of ABS and ammonia and the chemical oxygen demand were from half to two-thirds as high as during the period immediately before the

surfactants quantitatively, the results indicate that a major fraction of the total extractable organics consisted of ABS.

Threshold odor determinations during the period Jan. 22–Mar. 19 showed predominantly a musty odor in both the raw and treated water. The maximum threshold odor number in the treated water was 16 and, as a rule, the treated water had a higher thresh-

TABLE 10

Comparison of Organic Materials Recovered by Carbon Filter Method From Chanute Tap Water With Those Recovered From Other Waters of Varying Pollution

City or River*	Water	Organics Recovered—ppb		
		Chloroform Extract	Alcohol Extract	Total Extract
Chanute, Kan.	Tap†	214	778	992
Chanute, Kan.	Tap‡	121	600	721
Columbia River	Raw	33	87	120
Detroit River	Raw	201	264	465
Merrimack River	Raw	322	421	743

* Columbia River was sampled at Bonneville Dam, Detroit River at Wyandotte, Mich., and Merrimack River at Lawrence, Mass. River water data from Middleton, Rosen, and Burttschell (*8*).

† For sampling period Feb. 19–Mar. 3, 1957. Volume filtered, 6,048 gal.

‡ For sampling period Mar. 4–Mar. 22, 1957. Volume filtered, 6,530 gal.

old odor number than that of the raw water.

Other Analyses

As noted previously, the water at Chanute is fluoridated to 1.0 ppm. Normally, the raw water contains about 0.3 ppm of fluoride. During the recirculation period, the fluorides in the intake pond increased to about 0.8 ppm. The desired concentration in the tap water was maintained by decreasing the quantity of fluoride compound added in water treatment.

Table 11 gives typical complete chemical analyses of tap water before, during, and after the recycling of water. The increase in sodium concentration from a normal value of 30–60 mg/l to about 380 mg/l is notable. This has some significance for persons with cardiac ailments requiring a restricted sodium diet.

Coliform Organisms

The number of coliform organisms in the raw water during recirculation was considerably less than that found in Neosho River water at Chanute under normal conditions. This is shown by Fig. 11, which gives the MPN of coliform bacteria per 100 ml in the Chanute raw water from May 1956 through July 1957. The portion of the curve from Oct. 14 to Dec. 21, 1956, reflects the efficiency of sewage treatment and the stabilization pond. The portion of the curve from Dec. 21, 1956, to Mar. 14, 1957, shows the increased efficiency resulting from chlorination of the sewage treatment plant effluent. The highest raw-water MPN for the period during which the sewage effluent was being chlorinated was 330, and the average was near 20. For the periods shown before and after recirculation, the MPN sometimes exceeded 9,000 per 100 ml and averaged about 1,500.

After chlorination of raw water was started at the water plant on Dec. 20, 1956, the water in the first basin had an MPN of less than 3.0 per 100 ml

TABLE 11

Comparison of Typical Chemical Analyses of Tap Water Made Before, During, and After Recirculation of Sewage Treatment Plant Effluent at Chanute

Analysis	Before	During	After
Calcium	25	44	30
Magnesium	11	17	8.0
Sodium	59	379	30
Silica	3.0	6.5	10
Iron	0.20	0.19	0.06
Manganese	0	0	0.00
Hardness, total	108	180	108
Hardness, carbonate	39	174	76
Hardness, noncarbonate	69	6	32
Alkalinity, total*	39	174	76
Alkalinity, $NaHCO_3$*	0	0	0
Carbonate	3.6	24	3.6
Bicarbonate	40	163	85
Sulfate	101	89	49
Chloride	63	520	28
Nitrate	1.9	2.7	6.2
Fluoride	0.4	1.1	0.9
Total Solids	305	1,139	208
Turbidity	5	1	Under 1
pH	8.4	8.6	8.4

* In milligrams per liter $CaCO_3$.

as shown by examination of 14 samples tabulated in Table 12.

From Oct. 14, 1956, to Mar. 14, 1957 (the recycling period) 560 10-ml portions (112 samples) of tap water were examined in accordance with *Standard Methods* in the water and sewage laboratory at Lawrence. Only one tube or 0.23 per cent of the 10-ml portions examined was positive. This sample was collected on Nov. 24, 1956, before the beginning of chlorination of the sewage treatment plant effluent and prechlorination of the raw water.

In addition, eleven special samples each of raw and treated water were collected from the Chanute water treatment plant during February and March 1957. These samples were iced and transported to the laboratory at Lawrence for planting the same day. They were examined for coliform bacteria by both the immediate MF and MPN dilution procedures. Portions of each sample were also filtered through two membrane filters, placed on an inhibiting medium, and sent to the sanitary engineering center for incubation and examination.

The MF examinations of the raw water were made by filtering 10- to 50-ml portions of each sample through each of two membranes. The MPN dilution examination involved five portions each of 10, 1, 0.1, and 0.01 ml, confirmed test. Treated-water data were based on 100- to 200-ml portions filtered through each of two membrane filters, and that for MPN procedure on ten plantings of 10-ml portions, confirmed test. The results are shown in Table 13.

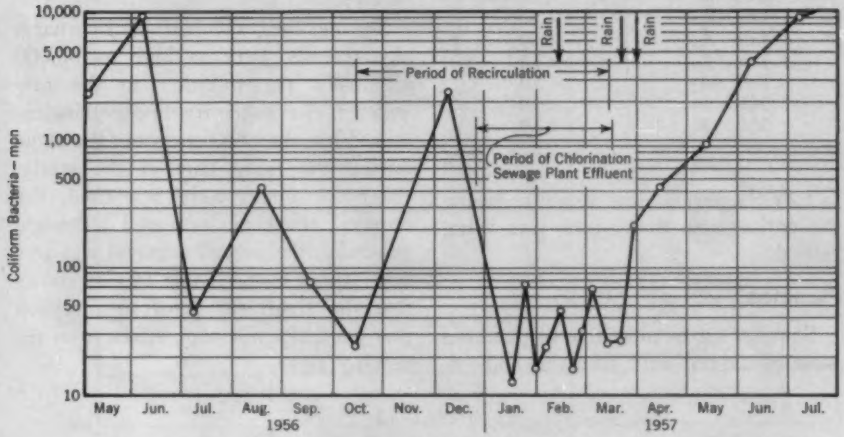

Fig. 11. Coliform Bacterial Densities in Raw Water

Number of organisms found in raw water during recirculation was considerably less than that in Neosho River under normal conditions.

Coliform bacteria were detected in the treated water on three separate days—twice by the immediate MF procedure and once by the delayed MF method. Coliform bacteria were never detected by more than one procedure in any one treated-water sample. The maximum density reported was only 1 per 100 ml. Thus, the tap water, as judged by standard tests, was of satis-

TABLE 12

Coliform Bacteria in Prechlorinated and Settled Water Plant Effluent at Chanute

Date 1956–57	*MPN*
Dec. 23	<3.0
Dec. 24	<3.0
Dec. 25	<2.1
Dec. 26	<2.1
Dec. 27	<2.1
Dec. 28	<2.1
Dec. 29	<2.1
Dec. 30	<2.1
Dec. 31	<3.0
Jan. 1	<3.0
Jan. 2	<2.1
Feb. 16	<3.0
Mar. 6	<3.0
Mar. 8	<3.0

factory bacteriological quality during the entire time that water was being reused.

Plankton

Samples for examination of plankton were preserved with formalin and examined without concentration in a Sedgwick-Rafter counting cell under 100 × magnification. Fig. 12 and Table 14 show results of the plankton counts.

Algal forms were abundant in the stabilization pond in spite of the relatively low temperature. The average water temperature during January and February was 42°F. A small green alga—*Ankistrodesmus*—was the dominant form. It has a volume of about 80 cu μ.

During the first half of February, algal counts were as high as 40,000 organisms per milliliter in the raw water. The water treatment plant removed less than 80 per cent of the algae during the early part of the study. After the filters were reworked, the removal efficiency increased although, generally, the overall removal was less than 90 per cent. Table 14 also shows that the treatment prior to filtration was generally not very effective in removing algae.

TABLE 13

Coliform Densities Obtained With Different Procedures During Water Reuse at Chanute

Date* 1957	Coliform Densities in Raw Water			Coliform Densities in Tap Water		
	Immediate MF Procedure	Delayed MF Procedure	MPN Dilution Procedure	Immediate MF Procedure	Delayed MF Procedure	MPN Dilution Procedure
Feb. 4	10	10	4	−0.5	0.5	−1.0
Feb. 6	26	14	17	−0.5	−0.5	−1.0
Feb. 11	26	64	33	−0.5	−0.5	−1.0
Feb. 13	45	120	49	0.5	−0.5	−1.0
Feb. 19	57	150	330	1.0	−0.5	−1.0
Feb. 20	85	180	33	−0.5	−0.5	−1.0
Feb. 26	75	60	49	−0.25	−0.25	−1.0
Mar. 5	15	30	49	−0.33	−0.33	−1.0
Mar. 12	15	65	—	−0.33	−0.33	—
Mar. 19	40	65	49	−0.25	−0.25	−1.0
Mar. 26	75	140	49	−0.25	−0.25	−1.0

* Figures after and including those for Feb. 19 are for period after resumption of flow of Neosho River.

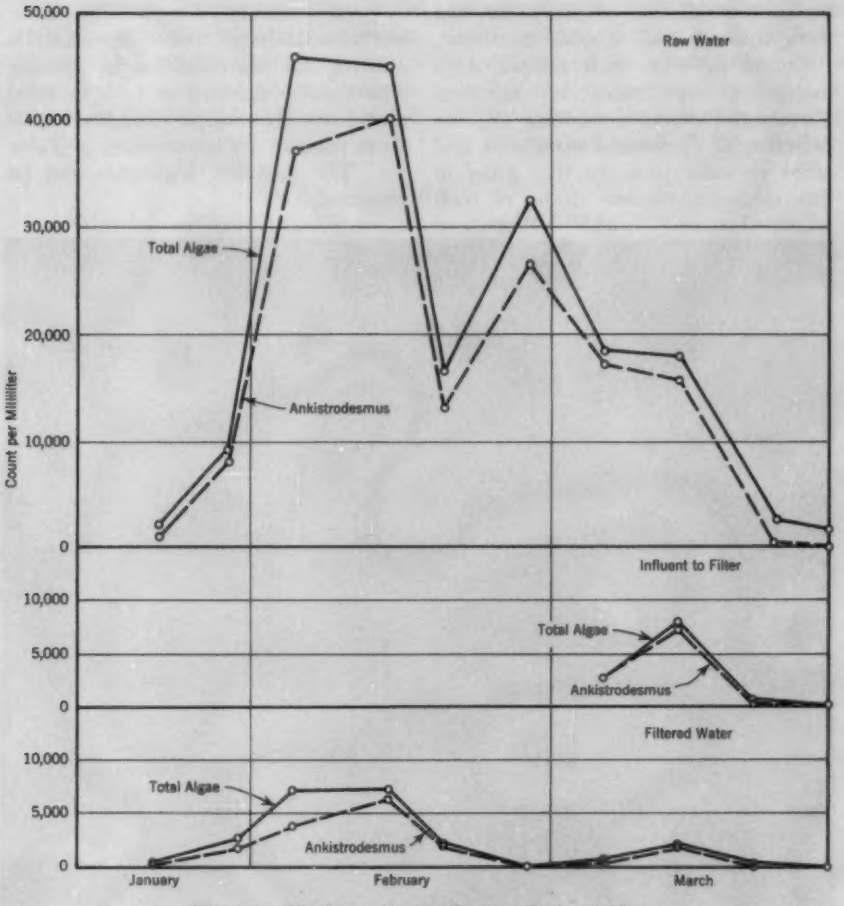

Fig. 12. Plankton Counts During Recirculation

Samples were examined under 100 × magnification.

Zoological Organisms

One-gallon samples of sewage effluent and raw water were concentrated in a centrifuge *; 1-gal samples of finished water were concentrated by filtering through membrane filters. In addition, 5-gal concentrates from finished water were prepared at the treatment plant. A general survey type of examination under low magnification was made of every concentrate collected for worms and other large zoological organisms. When the concentrates of finished-water samples contained algae and dead particulate matter in quantities which did not interfere with pro-

* Manufactured by the Sharples Corp., Philadelphia, Pa.

tozoa examination, these organisms were counted and roughly identified.

Concentrates of each sample were inoculated into tubes of modified Cleveland *Endameba* medium (*9*) for detection of *Endameba histolytica* and other parasitic protozoa that grow in this medium. A few drops of each concentrate from finished-water samples were planted on buffered sucrose nitrate agar for detection of live cysts of free living (nonpathogenic) amoebas. A favorable bacterial flora was used in the former and *Proteus mirabilis* was used in the latter detection.

Positive cultures for parasitic protozoa were subjected to iron-hematoxylin staining for identification of species. The results obtained in both cultural and direct microscopic examinations of these samples are summarized in Table 15. The following highlights may be observed.

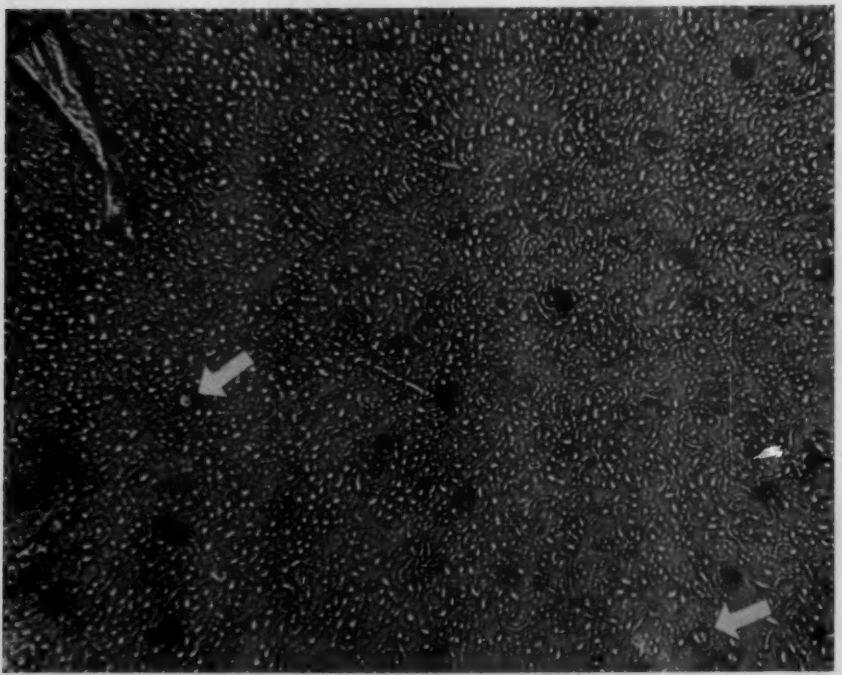

Fig. 13. Photomicrograph of Concentrate of Finished Water Sample

Samples, collected Feb. 4, 1957, shows two amebic cysts (arrows), Ankistrodesmus *and* Euglena *(round black objects). Magnification is 500 ×. Field includes material from about 15 ml of water.*

On one occasion, *Endameba histolytica* was detected in the sewage effluent. On two, *Trichomonas* was detected in the sewage effluent, once accompanied by another intestinal flagellate, *Chilomastix mesnili.* On one other occasion, the raw water was found to contain

Trichomonas. The occurrence of these parasitic protozoa in only three of ten samples of sewage effluent indicates that these organisms were relatively scarce in Chanute sewage during the study.

in removing particulate matter in the 5–20 μ range. Figure 13 is a photomicrograph of the concentrate from a finished-water sample collected Feb. 4, 1957. Two amebic cysts are indicated by arrows and most of the other organisms shown are the small algae *Ankistrodesmus.* The larger round black objects are *Euglena.* The field shown includes material from approximately 15 ml of water.

TABLE 14

Plankton Counts for Raw, Settled, and Filtered Waters During Water Reuse at Chanute

Date* 1957	Raw Water	Influent to Filter		Filtered Water		Treated Sewage
	Organisms per Milliliter	Organisms per Milliliter	Percentage of Raw Water Count	Organisms per Milliliter	Percentage of Raw Water Count	Organisms per Milliliter
			Total Algae			
Jan. 22	2,400			520	22	1,600
Jan. 29	9,300			2,600	28	1,900
Feb. 4	46,000			7,100	15	1,200
Feb. 13	45,000			7,100	16	880
Feb. 18	17,000			2,200	12	1,300
Feb. 26	33,000			200	1	530
Mar. 5	19,000	2,800	15	610	3	400
Mar. 12	18,000	7,900	44	2,100	12	1,400
Mar. 19	2,900	580	20	160	6	90
Mar. 26	2,000	170	8	50	2	90
			Ankistrodesmus			
Jan. 22	1,300			360	28	1,100
Jan. 29	8,200			1,900	23	110
Feb. 4	37,000			3,900	11	580
Feb. 13	40,000			6,200	16	880
Feb. 18	13,000			2,000	15	1,100
Feb. 26	32,000			60	0.2	400
Mar. 5	17,000	2,700	16	560	3	180
Mar. 12	14,000	7,400	53	2,000	14	880
Mar. 19	440	130	30	80	18	0
Mar. 26	180	60	33	30	17	40

* Figures after and including those for Feb. 18 are for period after resumption of flow of Neosho River.

In nine of the ten samples of finished water live cysts of free living (nonpathogenic) amoebas were detected. The presence of these cysts as well as significant numbers of algae in the finished water shows the relatively low efficiency of the water treatment plant

In the third and eighth samples (Table 15), a few live larvae of

Anguillula-like nematode worms were found in the finished water. These worms were identified as *Monhystera* and were given the species name, *Monhystera aquaticus*. Most of the worms found in the raw water were dead but a few live ones were almost always present. They are relatively resistant to chlorine and, evidently, the chlorine doses used were insufficient to kill all of them.

TABLE 15

Results of Cultural and Direct Microscopic Examinations of Treated Sewage and Raw and Tap Waters at Chanute

Organism	Source	Date of Sample Collection*									
		Jan. 22	Jan. 28	Feb. 4	Feb. 12	Feb. 20†	Feb. 27	Mar. 5	Mar. 12	Mar. 19	Mar. 26
Cultural Findings‡											
Endamoeba histolytica	Tap water	N	N	N	N	N	N	N	N	N	N
	Raw water	N	N	N	N	N	N	N	N	N	N
	Treated sewage	N	N	N	N	N	P	N	N	N	N
Trichomonas sp.	Tap water	N	N	N	N	N	N	N	N	N	N
	Raw water		N	N	N	P	N	N	N	N	N
	Treated sewage	N	N	N	P	P	N	N	N	N	N
Chilomastix mesnili	Tap water	N	N	N	N	N	N	N	N	N	H
	Raw water		N	N	N	N	N	N	N	N	N
	Treated sewage	N	N	N	N	P	N	N	N	N	N
Free living amoeba	Tap water	P	P	P	P	P	P	N	P	P	P
Direct Microscopic Findings‡											
Free living amoebic cysts	Tap water	600/gal	300/gal	?	?	?	?	N	F	?	?
	Raw water	M	M	M	M	M	F	F	M	M	M
	Treated sewage	M	M	M	M	M	M	M	M	M	M
Free living ciliates	Tap water	N	N	?	?	?	?	N	N	?	?
	Raw water	M	M	M	M	M	N	F	M	M	M
	Treated sewage	M	M	M	M	M	M	M	M	M	M
Free living nonpigmented flagellates	Tap water	N	N	?	?	?	?	N	F	?	?
	Raw water	F	F	F	F	F	M	F	F	F	F
	Treated sewage	M	M	M	M	M	M	M	M	M	M
Free living worms	Tap water	N	N	2	N	N	N	N	2	N	N
	Raw water	F,D	F	F	F	F	F,D	F,D	F,D	F,D	F,D
	Treated sewage	M	M	M	M	M	M	M	M	M	M

* Volume of tap water examined was 1 gal from Jan. 22 to Feb. 27 and 6 gal from Mar. 5 to Mar. 26.
† Date of resumption of flow of Neosho River.
‡ Key: N, negative; P, positive or present; F, few; M, many; ?, no count—too many algae; D, dead.

Viruses

During the past several years there has been an increasing interest on the part of public health workers in the potential role of sewage and sewage-contaminated water in the transmission of human enteric viruses. This interest intensified in 1955 after the outbreak of infectious hepatitis in New Delhi (*10*) which resulted in an estimated 20,000–40,000 cases, and which apparently was spread by the treated water of the city. Certain laboratory studies (*11, 12*) demonstrate that the problem of removing viruses from water poses questions as to the adequacy of present methods of treatment, and the New Delhi epidemic gives rea-

son for additional concern with the problem.

The enteric viruses which are most likely to produce readily recognized diseases are well known—those of infectious hepatitis and poliomyelitis and, perhaps, the Coxsackie virus and the adenoviruses. Still other viruses which cause less severe diseases conceivably can be spread by a water supply and not be recognized by available epidemiological techniques. Nonspecific diarrheas or "grippe" probably rank next to the common cold as sources of discomfort and economic loss in man-hours. Yet these diseases are usually not severe enough to require treatment by a physician and—even more important—they are presently nonreportable diseases. As a result, the epidemiologist has no statistics available for assessing the morbidity of these diseases and the microbiologist is just beginning to acquire data and techniques for studying their causative agents.

In the past 5 years, more and more viral agents have been isolated from human feces; not only from cases of recognized disease but from a good proportion of the healthy population. A useful grouping of the enteric viruses can be made as follows:

1. Infectious hepatitis virus
2. Poliomyelitis virus (Three types have been described.)
3. Coxsackie virus (More than twenty types have been described.)
4. Adenovirus (About eighteen types have been described to date. They are responsible for upper respiratory and ocular disease and are found not only in throat secretions but in feces and sewage.)
5. ECHO (enteric cytopathic agents of human origin) viruses (These cytopathogenic agents of human origin usually have been isolated from apparently normal individuals while screening for incidence of polio virus. Some of these agents have been associated with aseptic meningitis and diarrhea in children but many have not been associated with any clinical disease. More than twenty types have been identified.)

This broad and simple classification scheme now includes more than 60 virus agents—all pathogenic—which may be excreted in the feces of man.

At least one type of each of these five major groups of viruses has been isolated from urban sewage—with the exception of infectious hepatitis virus. Failure to demonstrate this latter agent in sewage is undoubtedly only a reflection of the lack of a laboratory method capable of recognizing it.

Virus Isolation Technique

At Chanute, virus samples were collected, preserved, and shipped in the same manner as were other organisms—as shown in Table 1. A 500-ml portion of raw-sewage samples was homogenized in a blender for 2 min and then centrifuged at 10,000 rpm for 30 min. The top half of the supernatant from this centrifugation was carefully removed and recentrifuged in the same mannner. The top half of the supernatant from this centrifugation was also removed and 2,000 units of penicillin, 2.0 mg of dihydrostreptomycin, and 0.25 mg of aureomycin were added to each milliliter of supernatant. After standing 1 hr at room temperature, each of 25 monkey kidney tissue culture tubes was inoculated with 0.1 ml of the material and each of 25 additional tubes was inoculated with 1.0 ml of the material. The tubes were then replaced in the roller drum for 1–2 hr, removed, and the medium completely drawn off and replaced with fresh me-

dium. The tubes were then replaced in the roller drum for the duration of the experiment.

Treated-sewage, raw-water, and tap water samples were treated by alum flocculation (*13*) to concentrate the virus. A sample volume of 2,900 ml was used. The settled floc was packed by low-speed centrifugation and the supernatant removed. The floc was then mixed with 1.4 per cent sodium carbonate and held for 1 hr with intermittent agitation in order to elutriate the virus. The floc was again centrifuged at low speed and 10 ml of the supernatant was added to 90 ml of monkey kidney tissue culture medium. Two milliliters of this medium was then added to each of 50 monkey kidney tissue culture tubes and the tubes placed in a roller drum for 24 hr. The tubes were then removed and the medium completely withdrawn and replaced with fresh medium. The tubes were then replaced in the roller drum for the duration of the experiment.

Rhesus monkey kidney tissue cultures—about 6 days old—were used to detect those enteric viruses known to produce cytopathogenic effects. These tissue cultures are susceptible to all three types of poliomyelitis virus, to the ECHO viruses, to at least some of the adenoviruses, and to most of the Coxsackie B viruses. The majority of the samples were also inoculated into suckling mice to detect the presence of Coxsackie A viruses.

Results of Virus Tests

Table 16 summarizes the results of virus examination of all samples. Two definitely positive isolations were made from treated sewage collected on Jan. 22 and Jan. 29, 1957. These two isolations produced a characteristic polio or Coxsackie-like cytopathogenic effect in monkey kidney tissue cultures. The table also shows six other samples as yielding questionable results. The cytopathogenic effects observed in these tubes are unlike anything seen at the sanitary engineering center laboratory before, and it is believed that they may be the result of viruses present in the monkey kidney tissue cultures and not from the inoculating material. Final identification of all of these viruses should help to clarify their original source.

Although only two of the 40 samples examined have yielded positive results for viruses, it is of interest to

TABLE 16

Isolation of Viruses From Chanute Water and Sewage, Jan. 22–Mar. 26, 1957

Sample	Collection Dates									
	Jan. 22	Jan. 29	Feb. 4	Feb. 11	Feb. 19	Feb. 26	Mar. 5	Mar. 12	Mar. 19	Mar. 26
Raw sewage	–	–	?	?	–	–	–	–	–	–
Sewage plant effluent	+	+	–	?	–	–	?	–	–	–
Water plant influent	–	–	?	–	–	–	?	–	–	–
Treated water	–	–	–	–	–	–	–	–	–	–

* Key: +, cytopathogenic agent; –, no change; ?, experiments not yet completed.

calculate the amount of virus present in the original sample.

The sewage treatment plant effluent collected on Jan. 22, 1957, produced four positive tubes of 50 inoculated. Preliminary tests indicate that these four tubes included viruses of the ECHO, Coxsackie and poliomyelitis groups. In this sample, the virus content of the whole 2,900-ml original volume was concentrated to about 10 ml and introduced into the tissue culture tubes. Considering the efficiency of the concentration procedure as 100 per cent, only four infectious doses were present in the original material—assuming that only one infectious dose of virus was introduced into each tube. In experiments not yet completed, however, the concentration procedure used in this study has been shown to be only 10–30 per cent effective in recovering virus. If a 20 per cent efficiency is assumed, the four infectious doses actually represent an original concentration of twenty.

The sewage treatment plant effluent collected on Jan. 29, 1957, produced only one positive tube of 50 inoculated. This has been identified as a poliomyelitis virus. Using the assumptions described above, the original 2,900 ml of treated sewage contained five infectious doses of virus.

These results are in general agreement with the data reported by Kelly (*14*) on her recent survey of enteric viruses in sewage. Her studies were made from June 1954 through May 1955. She reported a total of about 135 positive enteric virus isolations from raw and treated sewage. Only four of these were made during the months of January through March. By far the greatest number of positive isolations were made during the "poliomyelitis season"—July through October. None of the treated-water samples examined showed the presence of virus.

Effects on Health

There were no known cases of water borne disease or other adverse effects upon health resulting from the use of the recirculated water. The evidence supporting this conclusion is only presumptive, however, since no systematic morbidity studies were carried out. Because of the sensitive public relations and public opinion problems involved, it was decided that a subsequent study rather than one carried on during the recirculation period would be preferable.

On Jan. 29, 1958, representatives of the state board of health met with the local medical society. The results of the special study were reported to the physicians and their comments solicited. They were specifically questioned about their clinical observations during the period of water reuse. The general conclusion was that no illness could be traced to the reclaimed water supply. They reported that stomach and intestinal disturbances were much more prevalent and widespread in the fall and winter of 1957–58 than during the same period the previous year when water reuse was practiced. The physicians were, of course, fully aware of the possibilities and alert for any indication of trouble. Patients were also cognizant of the situation and there was a general tendency to blame almost any kind of sickness—particularly stomach or intestinal disorders—on the water. One physician reported that his patients had complained of dermatitis from bathing in the water.

The clinical observations by local physicians and the laboratory data are in agreement as to the safety of the water. The tap water met the Drinking Water Standards (*15*) for bacteriological quality during the entire period, and the special biological tests did not reveal the presence of pathogenic organisms. In evaluating the laboratory evidence, however, it is well to keep in mind the limitations of the techniques available at present, the difficulties involved in the isolation of specific disease-producing organisms, and the possible limitations of the coliform test under the prevailing conditions.

The chemical quality of the water became progressively worse during recycling. Again, no harmful effects were reported. The total solids content of 1,000–1,200 mg/l might have produced laxative effects on persons from outside the community not accustomed to use of highly mineralized water. Local residents were apparently not affected, probably as a result of the fact that the slow buildup in total solids occurred over several weeks.

The high sodium content of the water—about 380 mg/l—was significant for patients under restricted sodium therapy. For the great majority of persons in normal health, the additional sodium was no problem since properly functioning body organs adjust output rapidly and precisely to conform with intake. Some persons, however, with one of several very common diseases of the heart, kidneys, and liver are unable to rid themselves of sodium. Depending upon the severity of the disorder, special diets are prescribed limiting sodium intake from 0.25 g to 2.5 g. Because water is one of the major dietary sources of sodium, such patients are usually advised to use distilled water for drinking and culinary purposes. For this reason, it is doubtful that the high sodium content produced any actual effects, even on these few persons.

Consumer Acceptance

Initial public acceptance of the water was good, probably because the citizens knew that their supply normally received diluted treated sewage from seven upstream communities. No public mention of the move was made until after recirculation had been started. Public reaction became more adverse when stories appeared in the local newspapers. Bottled-water sales flourished and virtually all grocery stores carried a large stock. Exact figures on the total of bottled water sold are not available, but one of the two major distributors reported a sale of 40,000 gal in 5-gal containers at 20 cents per gallon plus $1.50—unrefunded—for the bottle.

More than 70 private wells were drilled, but most of the water pumped from them was too highly mineralized for domestic purposes and was used primarily for car washing, sprinkling, and other purposes for which use of city water was prohibited. Water was hauled from neighboring towns and farm wells by some people. The city and the Santa Fe railroad hauled a total of 150,000 gal of water into the city and made it available—at a central location—free to the public for drinking purposes. One cement plant which could not use high-chloride water, hauled 20 mil gal of water in a 9-day period at a cost of $100,000.

Shortage Prevention Plans

City officials are anxious to prevent a recurrence of the water shortage. They have initiated studies of possible sites for storing water on tributaries but have not yet proceeded with detailed planning. The John Redmond and Council Grove reservoirs have been authorized by Congress for flood control. Planning is under way and construction funds are being requested by the US Army Corps of Engineers for July 1958. Both of these upstream reservoirs on the Neosho River will have conservation pools for maintaining minimum flows. Because their construction will make a reservoir for the city unnecessary, Chanute officials are supporting the engineer corps' construction budget before Congress.

Summary

In 1956–57, during the most severe drought in Kansas history, the city of Chanute, on a temporary emergency basis, recirculated treated sewage through a stabilization pond, the water treatment plant, and the water distribution system. One complete cycle required about 20 days.

The recycling process was employed for 5 months in the fall and winter of 1956–57. During the first 2 months, the only special treatment provided was recirculation within the sewage treatment plant to obtain a better effluent. Further safeguards added during the last 3 months of operation included chlorination of the sewage plant effluent, prechlorination of raw water, the installation of a continuous chlorine residual recorder, and more frequent bacteriological testing.

There were no special problems in the operation of the sewage treatment plant. The water plant impounding reservoir served very effectively as a waste stabilization pond. In the 17 days retention provided by this intake pool, substantial reductions were obtained in BOD, chemical oxygen demand, total and ammonia nitrogens, and detergents.

Difficulties at the water treatment plant included:

1. The inability to practice free residual chlorination for taste and odor control and color removal because of the extremely high chlorine demand of the raw water
2. Frothing at the recarbonation basin and in the rapid sand filters during backwashing
3. Less effective coagulation and settling
4. Plugging and coating of the filter sand
5. False high readings of free-chlorine residuals obtained by the (OTA) test.

The treated water had a pale yellow color and an unpleasant musty taste and odor. It foamed when agitated and contained undesirable quantities of dissolved minerals and organic substances.

When the quality was at its worst, the raw water contained 17 mg/l nitrogen, 5.8 mg/l ABS and had a BOD of 13. Chloride concentrations increased from normal values of about 40 mg/l to a peak of 670 mg/l. The average increment per cycle was about 32 mg/l. Sulfates increased, on the average, about 26 mg/l from treated water to treated sewage. The total-solids content of tap water increased from a normal of 200–500 mg/l to 1,000–1,200 mg/l.

Carbon filter sampling of tap water during periods not representative of

the most severe conditions showed average concentrations of extractables of 159 ppb for chloroform, 685 ppb for alcohol, and 844 ppb total.

The number of coliform organisms in the raw water during the period of recirculation was less than that found when the Neosho River is flowing at Chanute. The tap water met the Drinking Water Standards for bacteriological quality throughout the period of reuse.

Algae in the raw water varied from 2,000 to 45,000 per milliliter. The predominant organism was the very minute green alga *Ankistrodesmus* which was poorly removed by water treatment.

The concentration of *Endameba histolytica* and other parasitic protozoa in Chanute's sewage was low during this period and these organisms were not found in the treated water. Cysts of free living amoebas comparable in size to *Endameba histolytica* were found regularly, however, in the treated water, indicating relatively low treatment plant efficiency in removing such organisms.

Two positive isolations of virus were were made from treated-sewage samples. These samples contained viruses of the poliomyelitis, ECHO, and Coxsackie groups. No virus was detected in the treated water. There were no known adverse effects on health from use of the recirculated water.

Consumer acceptance of the water was poor, and many persons obtained their drinking water from other sources. One industry—a cement plant which could not use high-chloride water—spent $100,000 in hauling 20 mil gal of water during a 9-day period.

Conclusions

The reuse of sewage treatment plant effluent to supplement deficient water supplies should not be considered or permitted except under the most severe emergency conditions. It is certainly a last resort, to be used only after all other possible sources of supply have been fully investigated.

With the degree of treatment provided at Chanute, it is doubtful that the process could have been continued for more than a few weeks beyond the 5-month period.

The most serious problem is that of public acceptance or—more accurately—public rejection of the water, although there are also serious technical difficulties to be overcome. People are willing to pay many times the normal cost to get a safe and palatable water.

The accumulation of nitrogen makes free residual chlorination impractical and renders tests, odor control, and color removal difficult.

The studies demonstrate the effectiveness of chlorine as a disinfectant, even under very adverse conditions. Bacteriological quality as judged by the coliform test was excellent.

A rapid increase occurs in the concentrations of dissolved salts and organic materials, many of which are not amenable to removal by ordinary processes. More information is needed on how effective more elaborate treatment may be in removing some of these pollutants.

There are many unresolved questions concerning the safety of recycled water from a public health standpoint, despite the apparently favorable results obtained in the Chanute study. Standard techniques available to water plant laboratories are not adequate to detect

the presence of some pathogens which may be present in heavily polluted waters, and the health significance of some of the organic chemical contaminants which may be present is not known.

Acknowledgment

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Discussion

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Within a few years, no doubt, professional and aesthetic acceptability of water reuse will be encouraged by the coining of a new term for sewage. Of more value, however, will be accurate reporting—even publicizing—of the physical, chemical, and biological differences between the first water, the used supply, and the reclaimed water. Furthermore, the limitations in reuse of municipal waste water should be

clearly shown. The Chanute episode and the resulting scientific report constitute a major demonstration of such a procedure.

The psychological reactions of the city authorities and the water department staff at Chanute, of state personnel at Lawrence, and of those in the federal department at Cincinnati—if all were known—would be very interesting. Some are frankly admitted in the report and others can be read between the lines. The remainder can safely be left to the reader's professional imagination.

The public at Chanute accepted the situation but, to a major degree, rejected the water for human consumption. The episode was a major and reasonably successful test in public relations and of confidence in the public water supply profession.

Health Factors

No one became sick—or, at least, so it seems, for if anyone did, it was not possible to assign the cause to the city supply, to water from private wells, or to bottled water. There were no waterborne epidemics. If there had been, it is difficult to say who would have been responsible. It is pleasant that these questions did not have to be answered, but raising them emphasizes the responsibility of the profession in delivering not only a safe but also an aesthetically acceptable water.

The coliform index of safety held—that is, when there is fewer than one coliform organism per 100 ml there are no waterborne epidemic. This is attributed to the old standbys of heavy chlorination, coagulation, long sedimentation, filtration, and postchlorination. It is felt, however, that the margin of safety was uncomfortably narrow.

The parasitologist and virologist members of the team exhibited considerable professional courage in attempting to demonstrate reduction of pathogenic protozoa and viruses in the cycle of sewage and water treatment processes. The results attest to the high professional level of their work. The failure to demonstrate the presence of pathogens in the finished water gives us confidence in its safety. The micro- and ultramicrobiologists, however, would be the last to claim that the absence of the pathogens had been proved.

A startling aspect of the microbiological observations is the demonstration of the low efficiency of the water treatment processes in reduction of the number of plankton, free-living ameba and their cysts, and other free-living organisms. The writer has confidence that infectious quantities of bacterial, protozoan, or viral pathogens would not have reached the water consumers' taps, even if very large numbers had been in the sewage plant influent, but it is interesting to consider what might have been the results if large numbers of pathogens had reached the water plant intake. Perhaps the effectiveness of conventional water treatment processes should be reevaluated.

Mineral Buildup

From a first study of the analytical data, the mineral buildup (Table 2) in the raw water from Jan. 15 to Feb. 13 seems very small. Considering the estimated 20:1 dilution of 0.75 mgd of sewage plant effluent in the lagoon, however, a daily increment of 30 ppm chloride from tap water to sewage effluent would produce only 1.5 ppm increment in the 15 mil gal of lagoon water,

or a total increment of only 40–50 ppm in the 29-day period. It is, therefore, not surprising to see chloride analyses of 510 and 500 ppm for grab samples collected on Jan. 15 and Feb. 13, respectively. Similar considerations of the total-solids data suggest an explanation of why the analyses indicate a total-solids buildup of only 100 ppm in the raw water (Table 9).

The calculated 29-day increment of sulfate in the total raw-water volume would be approximately the same as for chloride—50 ppm. This is sufficient to have registered a measurable increase in the raw water over the regularly observed quantity of approximately 80 ppm. It seems plausible that metabolic (anaerobic) reduction of sulfate to a lower state of oxidation prevented a buildup in sulfate.

Pollution Indicators

During the period Jan. 15–Feb. 13, there was a buildup in the raw water of each of the pollution indicator components except nitrite and nitrate (Tables 3–6). Observations for another month—with no rain—would have been interesting. In the summer, the nitrogen cycle might have been pushed far enough toward nitrate production to reach the dangerous level of 20 ppm nitrate nitrogen—a level sufficient to produce methemoglobinemia in infants.

The data, although admittedly meager, are probably the most complete available on the fate of phosphate and ABS through conventional sewage treatment plus lagoon stabilization, and the only data where the effects of water treatment processes are superimposed. These data will be of particular value to those interested in industrial utilization of municipal waste water.

There appears to have been a very slight reduction effected in ABS by water treatment and an approximately 25 per cent reduction by sewage treatment. Removal of ABS in the stabilization pond held the incremental buildup to 2 ppm (3.6–5.7, Table 4) in 29 days, whereas the calculated incremental contribution by the treated sewage was 9 ppm, indicating approximately 80 per cent removal of the ABS entering the lagoon during the period.

According to the analytical data, the water treatment processes were approximately 70 per cent effective and the sewage treatment 30 per cent effective in removal of total phosphate (Table 6). The incremental buildup of phosphate in the raw water during the 29-day period was only 2–3 ppm (Table 4), as compared with a calculated possible buildup of approximately 20 ppm. This indicates an 80–90 per cent removal of the phosphate entering the lagoon in the 29 days.

The buildup in BOD from 4.6 to 13 and the buildup in chemical oxygen demand from 44 to 71 in the 29 days were steady. There is a question as to how much BOD, chemical oxygen demand, ammonia, and total nitrogen are too much. These components plus the ABS were obviously approaching uncomfortable limits by Feb. 13.

An interesting relation is noted between the BOD and the chemical oxygen demand values on the raw sewage. Another question raised here is whether the BOD values—so consistently close to $\frac{1}{3}$ of those of the chemical oxygen demand—indicate that the latter test can be substituted for the BOD test on raw sewage. This should be studied in many laboratories on many sewages.

Free Residual Chlorination

Free residual chlorination would have been expensive, requiring perhaps more than a half ton per day of chlorine, but, supposedly, a price cannot be put on safe water.

Perhaps too much chloride buildup would have occurred in the raw water. An increment of 100 ppm chloride in the 0.75 mgd of treated sewage would have effected an increment of only 5 ppm in the 15 mil gal of water in the lagoon. This would have amounted to a 150-ppm increase of chloride per month in the raw water and ultimately would have made the water quite salty.

The control of chlorine dosage and residual would not have been too difficult, considering the long retention of the water in treatment processes. The writer believes that the use of free residual chlorination would have lessened the buildup of BOD and nitrogen components; in addition, water safety and acceptability would certainly have been improved.

Conclusion

If another test of the reuse of water is to be made, it should be done in the summer with competent scientists and engineers again present. Municipal waste water should be used with an activated sludge plant and free residual chlorination, and without the use of a stabilization pond.

Development of the AWWA Policy on Reservoir Use

Wendell R. LaDue

A paper presented on Apr. 21, 1958, at the Annual Conference, Dallas, Tex., by Wendell R. LaDue, Chief Engr. & Supt., Bureau of Water Supply, Akron, Ohio. The actual statement of policy appears in the May 1958 Journal.

AT a meeting on May 17, 1957, at Atlantic City, N.J., the AWWA Board of Directors accepted and passed the following resolution:

Resolved; that any decision on recreation, or other secondary uses of reservoirs, be left entirely to local discretion, and that the American Water Works Association register its opposition to state legislation relating to opening domestic water supply reservoirs to fishing or other secondary uses.

Many members of the Association, however, considered that this resolution was not sufficiently explicit to set forth the attitude of AWWA on this vital problem of recreational use of reservoirs. Consequently, an ad hoc committee was appointed by President Fred Merryfield, with six directors as members: E. Sherman Chase, Lewis S. Finch, C. F. Harnish, Karl F. Hoefle, L. D. Matter, and the author as chairman.

Background

The problem was fully studied and discussed by the members, and a statement of policy was formulated which was unanimously adopted by the Board of Directors on Jan. 26, 1958, at the annual meeting in New York. This statement of policy was published in the May issue of the JOURNAL (*1*).

The problem of the use of reservoirs, reservoir (marginal) lands, and watershed areas for fishing and other recreational uses has come before the purveyors of public water supply for some time with an ever-increasing tempo. The activities of recreation enthusiasts, fish and game clubs, and some wildlife officials have spread to the extent that they virtually insist upon having access to water storage reservoirs and marginal lands for recreational purposes. This, of course, has greatly perturbed members of the Association who operate water supplies and who realize that they alone are charged with the primary responsibility for safe and palatable water for public consumption.

The construction of improved highways throughout the nation, permitting automobile travel into rural territory, has resulted in opening up vast areas formerly considered inaccessible, but now accessible to ever-increasing numbers of the nation's citizens. Published material on this subject (*2–5*), together with a summary of 48 replies to an inquiry sent out by the Association to state sanitary engineers in Sep-

tember 1956, was studied by the committee members prior to formulation and presentation of the statement of policy to the Board of Directors.

Public Attitude

From the start, in the formation of the policy, the committee recognized that there were many elements to the problem. Public attitude toward ownership was one item for immediate concern. The attitude toward property of a publicly owned domestic water purveyor was found to be entirely different from that expressed regarding the property of a privately owned purveyor. The taxpayer—whether resident of the particular political unit or not—considers that he owns part of the public utility property and has a right to use it as he sees fit, subject only to the ordinary police powers of the political unit. Furthermore, if rules and regulations are prepared for orderly operation of the property, the basic thought of the American public to ignore minor policing restrictions makes it extremely difficult to police the use of a publicly owned water supply property. On the other hand, privately owned areas, although at times subjected to public misuse, nevertheless generally enjoy the respect due private ownership. It is believed that the American public respects privately owned property and necessary restrictive measures to prevent trespass. When such restrictions are relaxed to permit the public to enter some of the property for recreational use as part of a public relations policy, the fact is considered a privilege and is, in general, respected. The public knows that if the privilege is not respected it can be withdrawn. Any adverse publicity appears to reflect upon the public and not on the giver of the privilege. The difference in attitude may be strange, but it nevertheless exists.

Another element requiring attention was the policy of reforestation, which was generally conceded to protect marginal lands. On the other hand, it was claimed that the forest growth presented fire hazards wherever the public was permitted to trespass.

The ever-increasing population makes demands. More people, with more and more recreational time on their hands, are demanding access to what appear to them to be "wide-open" spaces. In regions of high population density, the demand for recreation areas is acute. At the same time, the need for prevention of pollution becomes most pressing. In general, a lack of understanding of the functions of these restricted areas results in pressure and friction. As a vital public function, the water utilities are called upon, as never before, to explain themselves and their purposes to the public. For that reason the Association's public information committee will prove a valuable asset.

Water Quality Control

The replies to the inquiry sent to 48 state sanitary engineers revealed some interesting sidelights on the subject of water quality control. As was expected, the replies are varied, depending on many factors in any particular area. As provided in the policy statement (*1*), utilities must assert, again and again, that "purveyors of public water supplies have always had the primary responsibility for providing the consumers with safe and palatable water. This traditional objective has

a major bearing upon the attitude which the water works executive takes when considering public entry to reservoirs and reservoir lands, which are dedicated to the highest benefit of the people served by the installation." There can be no voluntary relinquishment of this responsibility.

The purpose and responsibility of the purveyor are to maintain not only a safe water supply, but also an adequate supply at all times. This means that the demand on the stored water in a reservoir for public supply purposes has definite priority over the demand for recreational use. The problem, of course, is to convince the public of this axiom. The prevailing attitude of the layman, fostered by some well-meaning professional people, is that *any* water can be made satisfactory for human consumption.* Water utility men must be proud of their record, but the industry must be aware of its shortcomings. It becomes more apparent that the feeling of complacency, the feeling that present methods of treatment are sufficient for a "safe" water supply, may need a fresh study. Raw-water quality should be watched carefully. Currently, studies are being made as to the efficiency of filtration, with standard treatment, on the removal of organisms, and possibly viruses, from domestic water supply. Within recent years, more than 60 distinct virus strains may have been identified, which either produced disease or are associated with disease and are known to be excreted through the human alimentary tract. At the present time it is highly possible that there are no adequate methods of controlling these organisms and viruses or of removing them successfully from a raw-water supply. This accounts for the concern with raw-water quality.

If utility officials are to continue to supply a safe water, they must maintain control over reservoir use, or the responsibility can no longer be theirs alone. Who will assume it? Recreation experts, wildlife officials, public health executives, and water supply men, together, are now called upon to answer that potent question.

Local Application

As noted earlier, the Association now has a statement of policy regarding the subject of reservoir use. It is, of necessity, broad and all-inclusive, but, like the Association's standards, it must be applied locally with due understanding of its purpose and intent. A clue to practical application, on the local level, is found in the meaning of the word "policy" itself. A policy is not a regulation or a rule to be applied generally to all occasions. It is definitely subject to tailoring at the point of use and application. In the best sense, a policy represents wisdom, sagacity, and even shrewdness in the management of affairs. It indicates a desirable procedure in management, based on material and obligated interest in the outcome of the procedure. It prescribes the application of a certain amount of worldly wisdom in the formation of an adopted course, indicated by regulation and enforcement.

The adaptation of the policy to the individual water utility is not likely to be easy. It is, in fact, very difficult. Water utility executives are, in a sense, on the defensive, but public good and

* Support for this attitude is contained in the story of the use of reclaimed water at Chanute, Kan. See p. 1021, this issue.—Ed.

public benefit are on their side. These ideals of public good and public benefit must be fostered and expanded by the application and the securing of good public understanding of the industry's responsibility—and public responsibility as well.

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Coagulant Aids for Potable-Water Treatment

The USPHS Technical Advisory Committee on Coagulant Aids for Water has added the following product to the list of those which may be used for water treatment—in the concentration recommended by the manufacturer—with no adverse physiological effects on water consumers: Claron, manufactured by Allyn Chemical Co., Cleveland, Ohio.

The committee's findings bear only on the health aspects of the use of such products and do not constitute an endorsement or indicate their effectiveness in the proposed use. The names of other coagulant aids on the committee's list were published in the April 1958 issue of the Journal (p. 462).

Plastic Linings and Coatings for Steel Water Pipe

Graydon E. Burnett and Carl E. Selander

A paper presented on Apr. 22, 1958, at the Annual Conference, Dallas, Tex., by Graydon E. Burnett, Asst. Chief, and Carl E. Selander, Engr., both of the Div. of Eng. Labs., US Bureau of Reclamation, Denver Federal Center, Denver, Colo.

DUE to the inertness of many plastics to water, and other favorable properties, there has been much speculation as to whether they might not be especially well suited for lining and coating steel water pipe to protect it against corrosion. Logically, plastics could be compared with coal-tar enamel and cement mortar, the present AWWA coating standards. In substance, the question posed is whether plastic lining and coating would be better than current standards or as good at less cost?

In the past year the authors have conducted an extensive survey to collect data on this subject. In the survey they: [1] corresponded with many firms and individuals; [2] discussed the subject with coating applicators, piping contractors, representatives from major resin suppliers, and other individuals directly connected with the plastic-lined pipe field; and [3] made a review of the technical literature. It should be noted that, except for tapes and certain paint types, nowhere did the authors find that plastics are currently being applied for the specific purpose of protecting steel water pipe. There was, however, considerable activity in the use of plastics for protecting steel pipe for industrial uses, and this information was invaluable for an analysis of the prospects for using plastics on steel water pipe.

The term plastics is difficult to define to the satisfaction of all. It may cover a broad range of materials or be limited to a narrow range. For example, it has been suggested that waxes, coal-tar pitch, and asphalt are in effect plastics. For the purposes of this paper, however, plastics will include only organic synthetic materials obtained from chemical condensation, polymerization, or other reactions in which individual molecules combine in large numbers to create large molecules. The final plastic product may be either one of the thermosetting types, those that are stabilized by heat or chemical reaction and are not softened by additional heat, or one of the thermoplastic types, which soften under heat and harden when cooled. Typical examples of the thermosetting types are phenolics, epoxies, and polyurethanes; thermoplastic types are vinyls, polyethylenes, vinylidenes, polyfluorocarbons, and synthetic rubbers such as neoprene and thiokol. Both types of plastic have modifications introduced in the basic materials by the addition of plasticizers, fillers, drying oils, and other agents.

The use of plastic materials for protecting steel against corrosion is not new, even within the limited definition of plastics used in this article. A Chicago plant visited by one of the authors in 1940 applied baked phenolic plastic to steel, particularly as a lining for tank cars employed in transporting chemicals. Another plant visited in 1950, in Houston, Tex., applied baked phenolic linings to small-diameter steel pipe, for use in refineries and chemical plants. Although baked phenolics have probably been used most extensively, other plastics, notably vinyls, polyethylenes, polyfluorocarbons, synthetic rubbers, and epoxies, have also been employed in plant application processes.

The technical literature gave little information on plastic linings and coatings for steel pipe, with respect to application methods, serviceability, and cost. It is apparent that although plastics are being used for the protection of steel pipe, the firms doing this type of work are not yet ready to publish details of their processes, except in limited form in advertising brochures or publicity releases. This is not surprising, since many processes are still in an experimental or development stage, or are exclusive processes.

Requirements

Coal-tar enamel and cement mortar are already well established as long-life protective coatings for steel water pipe. Extensive use of plastics for this purpose will require that they be reasonably competitive in cost and service life. Although prices vary widely, it can be assumed that a moderately priced plastic material will cost about ten times as much as coal-tar enamel; say 50 cents a pound, as compared to 5 cents. To be competitive, a plastic lining or coating must, therefore, be effective at about 10 mils thickness, as compared with the usual requirement of about 100 mils for coal-tar enamel. This effective thickness must also be attainable at no significantly greater application cost. (Surface preparation by blasting, or by other rather expensive means, is considered a requirement for application of both materials. Unless otherwise specified, sandblasting is assumed to be the preparation method throughout this discussion.)

The price of $\frac{3}{32}$-in. coal-tar enamel coating may be considered to be: from 15 to 30 cents per square foot for interior linings; from 20 to 35 cents for exterior coatings with a 15-lb asbestos felt wrap and paper wrap, shop applied; from 35 to 60 cents for hand-daubed lining; and from 70 cents to $1 for hand-applied exterior coating with a felt wrap. Cement-mortar interior linings will cost from about 20 to 30 cents per square foot at thicknesses of $\frac{1}{4}$–$\frac{1}{2}$ in.; exterior cement-mortar coatings, applied at $\frac{3}{4}$-in. thickness with steel reinforcing, costs about 25–30 cents per square foot. Costs for cement mortar do not include sand-blast cleaning, since this is not usually considered necessary for this material. (The cost data given here and later, except where specifically referenced, were obtained through correspondence, from manufacturers' price lists, or by estimates based on the authors' experience. For accurate cost data for any particular coating or lining, it is suggested that applicators or the plastic manufacturer be consulted.)

So far as service life of plastics is concerned, due to the comparative newness of plastic coatings, the authors did not expect to find proof of extended life, comparable to existing records for coal-tar enamel and cement mortar.

Some excellent records of performance for paint-type plastics for periods close to 10 years are available, however. Phenolic and vinyl test coatings in the US Bureau of Reclamation's Shasta Dam penstock are still in excellent condition after 8 years' service (*1*). A recent bulletin reported excellent performance of vinyl coatings in a water-tank test after 8 years' exposure (*2*). Considering that these coatings are applied in relatively thin films—approximately 5 mils—it is reasonable to surmise that plastic linings, when applied at greater thicknesses could equal the long life of coal-tar enamel.

Although the vinyls and phenolics mentioned are paint-type coatings, in essence they are plastics in solution at the time of application and true plastic films when dried. Fusion and hardening occur in the drying processes, either by release of solvent, by polymerization, or by heat cure in the case of the baked coatings. Many regard these solution types of plastics as merely paints, and paints for many years have had the reputation of not being as effective as hot-applied coatings, particularly for the exterior of buried steel pipe. Observations of vinyl and phenolic coatings in soil-stress tests conducted by the bureau, however, have led the authors to believe that plastic coatings of the proper type and of adequate thickness are capable of providing effective protection to buried pipe. After 20 cycles of wetting and drying in the bureau's clay soil test, both vinyl and phenolic coatings 5 mils thick showed no adverse effect, and have permitted no rusting of the steel (*1*).

Adequate thickness of plastic coatings is necessary, not only to provide long life, but also to provide effective electrical insulation when cathodic protection is used. Most plastic materials have good dielectric properties and high volume resitivity (*3, 4, 5*), and it appears that adequate insulating effect can be obtained at around 10 mils thickness.

Damage to protective coatings on steel pipe during handling and shipping is always a problem. Plastic coating, therefore, should be reasonably immune to such damage, and, if damage does occur, should be easily repaired. One of the advantages of coal-tar enamel is the ease with which damage can be repaired. Facility of application of plastic coating to joints must also be considered.

Table 1 gives a cost comparison and other factors for plastic and nonplastic coatings.

Types of Plastics

No attempt will be made to name all types of plastics that might be considered for use on steel water pipe. Some of the more common plastics being used for coating steel pipe are phenolics, vinyls, vinylidene chloride copolymers, polyethylenes, polyfluorocarbons, epoxies, and neoprene and other synthetic rubbers. These will be discussed in some detail, although the pipes coated with these materials were not specifically intended as water pipe (actually some could so be used), but were designed to resist more highly corrosive environments.

Phenolics

Both air-drying and baked phenolic, paint type coatings are used; approximately 6 per cent of total phenolic resin usage is for protective coatings (*5*).

Brush- and spray-application procedures for the air-drying phenolics, such

as those furnished under federal and AWWA specifications, are common. The baked phenolics are applied to the interior of steel pipe by multiple coat-and-bake processes (*6*). Pipe from 2 to 12 in. ID can be lined by using regular equipment; larger sizes can be lined on special order. Thorough cleaning of the pipe, including steam, solvent, and sandblast, is provided first. Each coat is then applied by an in-and-out pass of a 360-deg spray lance, followed by oven baking at around 300°F. Each coat-and-bake cycle results in a film thickness of 0.5–0.7 mil. Final thicknesses are 5–7 mils, after a final bake at about 500°F, so that many passes and bakes are required.

TABLE 1

Comparison of Plastic and Nonplastic Linings and Coatings

Material	Use	Film Thickness	Place of Application	Pipe Size *in.*	Cost* *$/sq ft*
Plastic Linings and Coatings					
Phenolic, baked	Lining	5–7 mils	shop	2–12	0.70–0.85
Vinyl, solution type	Coating	5–7 mils	shop or field	any	0.25–0.35
	Lining	5–7 mils	shop or field†	6+	0.25–0.35
	Coating	10–15 mils	shop or field	any	0.45–0.55
	Lining	10–15 mils	shop or field†	6+	0.45–0.55
Polyvinyl chloride, sheet	Lining	$\frac{1}{16}$–$\frac{3}{16}$ in.	shop or field	large	2.00–5.00
Polyethylene, extruded	Coating	0.025 in. +	shop	4½ max.	0.20–0.45
Vinylidene chloride copolymer	Lining	0.159–0.250 in.	shop	2+	6.00‡
Tetrafluoroethylene	Lining	$\frac{1}{8}$ in.‡	shop	small	35.00‡
Epoxy, nonbaking	Coating	5–7 mils	shop or field	any	0.25–0.35
	Lining	5–7 mils	shop or field†	2+	0.25–0.35
Epoxy, baked	Coating	5–7 mils	shop	any	0.70–0.85
	Lining	5–7 mils	shop	2–12	0.70–0.85
Epoxy, coal-tar	Coating	25 mils	shop or field	any	0.35–0.60
	Lining	25 mils	shop or field†	2+	0.35–0.60
Neoprene, liquid	Lining	20–30 mils	shop or field†	2+	0.65–2.00
Neoprene, sheet	Lining	$\frac{1}{16}$–$\frac{3}{16}$ in.	shop or field	large	2.50–5.00
Polyethylene tape	Coating	12 mils	field	any	0.20–0.35
	Coating	20 mils	field	any	0.30–0.45
Polyvinyl chloride tape	Coating	10 mils	field	any	0.30–0.35
	Coating	20 mils	field	any	0.40–0.50
Nonplastic Linings and Coatings					
Coal-tar enamel	Lining	$\frac{3}{32}$ in.	shop	4+	0.15–0.30
	Lining	$\frac{3}{32}$ in.	field§	large	0.35–0.60
Coal-tar enamel with 15-lb asbestos felt and kraft paper	Coating	$\frac{3}{32}$ in.	shop	any	0.20–0.35
	Coating	$\frac{3}{32}$ in.	field‖	any	0.70–1.00
Cement mortar	Lining	$\frac{1}{4}$–$\frac{1}{2}$ in.	shop	4+	0.20–0.30
	Coating#	$\frac{1}{2}$–1 in.	shop	4+	0.25–0.30

* As applied, including cleaning.
† Shop application only for small-diameter pipe.
‡ Approximate.
§ Hand daubed.
‖ Hand applied.
With reinforcing.

Early applications were made with straight phenolic coatings, but these were subject to easy damage, and in some cases had poor resistance to alkali and to high pH solutions (*7*). Improvements in the phenolic resins and modifications, primarily with epoxy resin additions, have, since then, improved both the physical characteristics and chemical resistance of these coatings (*7, 8*). The complete baked phenolic lining will cost approximately 70–85 cents per foot. In the case of steel water pipe, provision would also have to be made for a protective material to be applied to the exterior of the pipe.

Vinyls

Vinyl plastic covers numerous articles, ranging from thin-solution materials through rigid preformed sheets and tubes. Air-drying types of vinyl, organosols and plastisols, preformed inserts, extruded outer liners, cemented sheet stock, and tapes will be discussed. The thin-film, paint type vinyl coatings, usually based on the chloride-acetate copolymer, have been used for many years. The bureau has used them to some extent for lining large-diameter steel water pipe where very low temperatures might damage coal-tar enamel. Normal paint-application procedure, brushing for the first coat and spraying for succeeding coats, is used. Multiple coats are required, usually from three to six, with final thicknesses ranging from 5 to 15 mils. Costs will vary from 25 to 35 cents per square foot for a three-coat system and from 45 to 55 cents for a six-coat system.

Recent developments in heavy-bodied, or high-solids, vinyl solutions have made greater thickness per coat possible, thereby reducing the number of coats required to obtain the desired final thickness. Special application techniques, such as hot-spray and hot high-pressure airless spray, are employed. No accurate cost data were available on these applications, but they should cost somewhat less than the thin-solution types. Since the high-solids vinyl solutions are relatively new, little service data are available.

High-solids vinyls may be readily applied to either the interior or exterior of pipe ranging in size from 6 in. ID and up. Interior lining of smaller-diameter pipe presents some problems, but can be accomplished.

Organosols and plastisols are vinyl chloride compounds of even higher solids content. The primary difference between the two is that organosols contain solvents which must be released after application, prior to the cure, whereas plastisols are 100-per cent potential-solids materials. Basically, plastisols are vinyl resins dispersed in plasticizers, with other ingredients added to give desired properties. Although they are still adaptable to spray application, plastisols must be heat-cured at about 300–360°F to form the final plastic film (*5, 9, 10, 11*). Many formulations are possible with the numerous resins, plasticizers, and other additives that can be used; by selective formulation, effective coating materials could probably be provided for both the interior and exterior surfaces of steel water pipe. An important advantage is that satisfactory thickness (10–20 mils) is possible in a single pass, thus greatly reducing application costs compared to the usual vinyls. On the other hand, cost of baking is added. Some difficulty has been experienced in developing an effective primer to make the coating adhere to steel, but several companies are working on the problem and success has been reported in test applications (*12*). With solution of the primer problem,

the organosols and plastisols might well find considerable application in lining and coating steel water pipe.

Although the use of vinyl inserts for steel pipe is not common, it has been reported. In this process, a preformed plastic tube is inserted into a pipe coated with adhesive, in order to obtain a permanent, flexible bond which can overcome differences in thermal expansion between steel and plastic. So far, the authors have been unable to obtain much information on this process.

Vinyl plastics, and other thermoplastic types, have been extruded in the melted state onto the exterior of steel pipe by machine, with a quench to cool and set the plastic. This also is not common practice, and no details or cost data could be obtained.

Linings with polyvinyl chloride sheet, both rigid and flexible types, could probably be used for protecting large-diameter steel pipe, but they are more commonly applied to large vessels and tanks. Sheet thicknesses range from $\frac{1}{16}$ in. through about $\frac{3}{16}$ in. Generally, the sheets are fastened to the steel with a nonhardening adhesive, and the joints are sealed by one of several means: solvent weld, cement weld, or heat weld of a strip of like material (*11*). Costs for such linings will vary from about $2.00 per square foot to around $4.50 or $5.00, depending on the thickness of the liner, the area to be lined, and the place of application—whether in the shop or in the field (*13*).

Polyethylene

Due to its low solubility, straight polyethylene is not used in solution-type coatings. At least one modified polyethylene resin, however, a chlorosulfonated polyethylene, has been so used (*9, 14, 15, 16*). A paint formulated with this resin is now under test in the bureau's paint laboratory, but sufficient data have not yet been gathered to evaluate it. Cost of the application is reportedly comparable to that of the solution-type vinyls. Polyethylene can be applied by flame-spray processes (*5, 14*), but the authors have received no reports of regular applications to steel pipe.

An interesting new development is the extrusion of polyethylene as an exterior coating for steel pipe (*17*). This process is designed for buried pipelines in the gas, oil, and chemical industries. It involves thorough cleaning of the pipe, a hot application of an elastic adhesive, and a controlled thickness of polyethylene extruded over the adhesive. Sizes coated range from $\frac{3}{4}$- to 4½-in. OD, and coating thicknesses range from 0.025 in. and up. The approximate cost of the coating is 20–45 cents per square foot. In most instances, such coated pipe would still require lining for use as water pipe.

Vinylidene Chloride and Polyfluorocarbons

Developed for use in the chemical-process industries, steel pipe lined internally with either vinylidene chloride copolymers or polyfluorocarbons (chlorotrifluoroethylene and tetrafluoroethylene) is prohibitively expensive for use as water pipe; but as they are true plastic-lined pipes, they are of interest.

Pipe sizes ranging from 1 to 6 in. are available with seamless vinylidene chloride copolymer plastic lining. A preformed plastic tube is inserted into an oversize steel tube or pipe and a cold-swaging operation locks the liner in place internally. During the swaging operation, the vinylidene chloride

liner is compressed, which results in densification; this reportedly improves the physical and chemical properties of the liner (*18*). For larger sizes, the pipe is lined with sheet stock of the copolymer by bonding a rolled sheet, with a skived lap joint, to the interior surface of the pipe with an adhesive. The lap is bonded and hot-stitched prior to insertion into the pipe. The pipe so lined is placed vertically and filled from bottom to top with hot water, expanding the liner against the pipe and forcing out entrapped air between the liner and pipe. The high temperature of the water activates the adhesive system to make bond (*19*). For still larger sizes of pipe, ordinary procedures for applying sheet stock with adhesive are used (*19*). Liner thicknesses vary from 0.159 through 0.250 in. The cost of vinylidene chloride copolymer lining is in the neighborhood of $6 per square foot (*18*). Assorted lined fittings and valves are also available for use with the pipe.

Not much information was obtained on the polyfluorocarbon-lined pipes and fittings. Thicknesses of the internal liners are around ⅛ in., with pipe sizes ranging from 1 to 4 in. One method of application involves a dispersion of resin in water, spray applied over a primer, followed by baking at 700–750°F (*9*). The tetrafluoroethylene liner costs about $35 per square foot, and sometimes more. Price data on the chlorotrifluoroethylene liner were not obtained.

Epoxies

The bureau's paint laboratory conducted a series of screening tests on twelve proprietary, amine-cured and ester type, epoxy resin, paint-type coatings. None of these coatings was satisfactory for steel submerged in water; early failure developed through blistering. Recent developments, however, particularly in combinations of epoxy resins with other components, such as polyamide resins (*5, 10, 20, 21*), phenolic resins (*5, 7, 8, 10*), and coal-tar (*5*), have resulted in coatings much improved in water resistance. The bureau has had several epoxy coal-tar coatings under test for some time, and all have performed satisfactorily, so far. The modifications, except for coal tar, cost about the same as the baked phenolics or solution-type vinyls, depending on whether baking or room-temperature curing was required. The epoxy coal tars are applied, in two or more coats, to a total thickness of about 25 mils. Costs for a 25-mil film will vary from 35 to 50 cents per square foot for a two-coat application, and from 45 to 60 cents for a three-coat application. The difference in cost can be attributed to the additional labor for an extra coat. Thinner films per coat are used on vertical or near-vertical surfaces to prevent sagging.

Synthetic Rubbers

A limited amount of data was obtained on neoprene, thiokol, and other synthetic rubber linings. Neoprene is usually applied by one of three methods: cold application of liquid neoprene, hot vulcanization, and adhesive bonding of cured sheet stock (*14, 16*). Spray applications of liquid neoprene to large tanks are reported to cost around $1.45–$2.00 per square foot for a 20-mil film; $2.10 is the reported cost for the same thickness, as applied to a 2-ft-square duct (*13*). These costs appear to be rather high, as the authors' experience with experimental spray and brush applications of liquid

neoprene would indicate a cost of around 65–85 cents per square foot for a 30-mil thickness. In all of the bureau's tests, neoprene has given good performance as a protective coating for steel in water.

Heat-cured neoprene and cemented neoprene sheet are thick linings that might be used for large-diameter pipe. Costs will vary considerably, depending on the thickness. A $\frac{3}{16}$-in. sheet lining will cost around \$4.50–\$5.00 per square foot (*13*).

Thiokol applied by flame-spraying has had considerable use by the Navy Department in its marine corrosion-prevention program. The authors, however, know of no applications of thiokol for the protection of steel water pipe.

A variety of other synthetic-rubber polymers are specially compounded to meet the needs of the chemical-process industries, and usually are used on large tanks and vessels. Hot vulcanization and sheet lining are the two common methods of application, and costs would be expected to be about the same as for similar neoprene applications.

Plastic Tapes

Judging from published reports, the use of plastic tapes for the protection of the exterior of steel pipe, mostly gas and oil pipe, is increasing. Several relatively long gas-transmission lines have been coated with plastic tapes in recent years (*22, 23, 24*). Both self-adhering tapes and those requiring a primer or adhesive are available. Polyethylene and polyvinyl chloride tapes are the most common. Self-adhering polyethylene tapes are supplied in 12-mil and 20-mil thicknesses, including the adhesive. The installed cost of a single wrap of a 12-mil tape is about 20–35 cents per square foot, and of a 20-mil tape, from 30 to 45 cents. Self-adhering polyvinyl chloride tapes are available in 10-mil and 20-mil thicknesses, including the adhesive, and will cost from about 30 to 35 cents per square foot for the 10-mil application, and from about 40 to 50 cents for the 20-mil wrap. These costs are based on power wirebrushing for cleaning. Usually, these tapes are applied mechanically in the field, just prior to installing the pipe in the trench. Non-adhering tapes which require separate adhesive are available in almost any thickness desired. Other tapes, such as polyvinyl chloride–butyl rubber combinations, are available, but the authors have only limited data on them.

Tests made by the bureau indicate good resistance to soil stress for plastic tapes (*1*). The tapes should be made and applied so that a good seal is obtained at overlaps and around fittings.

Application Methods

It is probable that to achieve serviceability equivalent to coal-tar enamel, plastic materials should be applied to at least 10 mils minimum thickness; 15–20 mils would be preferred. For economy, the final thickness should be obtained in the fewest operations possible, since multiple coats increase costs. Some of the methods employed to provide considerable thickness with a minimum of operations include:

1. The hot-spray processes involve heating of the material prior to spraying. This reduces the viscosity of high-solids, solution-type materials to spraying consistency, and permits quicker release of the solvents so that a heavier film can be applied in one pass (*25*).

2. In the hot, high-pressure, airless process, the hot solution is placed under pressure on the order of 700 psi, and atomized through a nozzle, without introducing air. Reportedly, this process has all of the advantages of the hot-spray process, and also reduces the amount of overspray usually encountered with solution-type materials (*26*).

3. Flame spraying involves the introduction of plastic in powder form through an oxyacetylene flame (*5, 14*). The plastic powder is partially melted as it passes through the flame, and fuses completely as it strikes the hot surface under the flame. A reducing flame is used during the application, in order to prevent oxidation of the plastic material. Some materials, such as vinylidene chloride and polyvinyl chloride, are reported to be not suitable for flame spraying, as porous films result (*27*). With this method, almost any desired thickness should be obtainable in one pass.

4. Finely divided powder may be melted and delivered to the surface in a hot-air stream (*28*). Again, any coating thickness can be obtained in one pass. This method is particularly suited to plant application.

5. Although possibly not suited to pipe coating, a new method of plastics application should be mentioned. This is a fluidized-bed process, wherein the article to be coated is heated above the melting temperature of the plastic, and then immersed into a fluidized bed of the finely divided material. Coating thickness is controlled by the time of immersion. The powder, as it contacts the hot metal, fuses and clings to the surface, gradually building the thickness to the desired point (*29*). It appears that this method would be particularly suited to coating fittings and valves, where odd shapes are encountered. The fluidized bed itself is a mass of finely divided material, of controlled particle size, within an open container through which air or inert gas under pressure is passed from bottom to top. The velocity of the gas is such that the particles are kept in rapid motion, which could be described as a bubbling motion. The gas velocity is near the free-settling velocity of the particles in air, so that they are kept in rapid motion, yet not blown off.

Other methods which are currently being used include: [1] extrusion directly onto the pipe; [2] extrusion of a preformed insert for subsequent application to the pipe; [3] application of sheet stock; [4] spray application of plastic dispersed in water, followed by fusion at elevated temperature; and [5] tape wrapping.

Lining Pipe in Place

Since about 1945, considerable work has been done in applying plastic linings in the rehabilitation of small-diameter steel pipe in the field (*30, 31*). Most of this type of lining has been installed in crude-oil pipelines; it has also been used on water pipe (*32*). Solution-type vinyls were used in early applications, but difficulties were experienced with washouts as the evaporating solvents collected and condensed down the line during the air-drying cycle. Developments in the high-solids, catalyst-cured, modified epoxy coatings have virtually eliminated this problem.

One of the main problems is attainment of a thoroughly clean surface to hold the lining. The following steps were reported to have been used to obtain a satisfactory cleaning job of a crude-oil line: [1] the pipe was flushed

with solvent; [2] mechanical, scraper-type cleaners were run through the line; [3] the line was given an alkaline wash, followed by an acid wash and water rinse; and [4] the line was flushed with methyl-ethyl–ketone and dried with forced air.

The lining is applied by extruding a film around the follower plug passing through the line (*30, 31*). Costs, no doubt, will vary considerably with job conditions. One job, using only mechanical cleaning followed by a solvent wash, and coating to 5-mil thickness, cost about 60 cents per square foot (*32*).

The possibilities of employing this method in a new pipeline, where cleaning costs would be at a minimum and joint areas would be covered in the process, should not be overlooked. Whether such a lining will perform up to full expectations without blast cleaning is questionable.

Joints

The protection of joints is an important part of lining pipe. Several methods are prescribed, or suggested, by the pipe-lining companies. With baked phenolic, or other fused linings, in small-diameter pipe, threaded couplings, either interior or exterior types, lined with a like material, are available. Such joints are potential weak spots, as incomplete coverage of the threaded area or damage to the coating during assembly can expose bare metal to the contained liquid. This type of failure has been reported in oil pipelines (*6*). The vinylidene chloride copolymer linings, and the polyfluorocarbon linings, are generally applied to pipe sections with flanged ends. The lining itself is formed to extend over part of the flange, so that when the pipe is assembled there is actually a plastic-to-plastic seal at the joints (*18, 19*). Mechanical couplings which provide for close contact between the ends of the lining in pipe sections may be adequate for water pipe.

The most common recommendation for protecting the exterior of pipe joints is to use one of the plastic tapes. Hot-applied bitumen has also been recommended. One company has developed a special mastic material that is hot-applied, but at a lower temperature than hot-applied, coal-tar enamel or asphalt. Plastisols cured under heat lamps have been suggested; an effective primer would, of course, be needed, just as for pipe surfaces.

Solution type plastic could be used for joint areas of large-diameter welded pipe. The protection, however, should be equal to that of the pipe itself, and a method of applying in the field the same plastic as on the pipe would be desirable for the joint areas.

Summary

A number of plastic materials and processes for lining and coating steel pipe have been discussed. Most of them appear to have favorable characteristics for protecting steel in contact with water. At the present time, however, they are not generally applied for the protection of steel water pipe, and many of them appear too expensive for practical consideration.

The authors cannot name any plastic lining or coating that has the proved durability of coal-tar enamel, or cement mortar, for the protection of steel water pipelines. It appears entirely feasible, however, that 10-, 15-, or 20-mil plastic coatings and linings can be provided to offer the desired protection, and still be reasonably competitive in cost.

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Inventory of 1956 Water Supply Facilities in Communities of 25,000 and Over

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INVENTORIES of water supply facilities in United States communities of over 25,000 population have been published by the USPHS for 1954, 1955, and 1956 (*1–3*), and summary statistical data for the two earlier years have been reported by Porges (*4, 5*). The report presented here gives summary data for conditions as of Dec. 31, 1956, and, for the first time, includes data from United States territorial possessions.

Porges (*5*) has reported in detail the history of the USPHS compilation and summarization of data concerning water supply facilities. As in the past, the data reported here were compiled with the active support and assistance of the various state health departments. This effective collaboration has produced consistently valuable data for many years.

The data for 1956 were summarized using modern, high-speed, punched-card tabulating equipment. This change from the use of marginal punched-card tabulating methods was carried out at this time to develop programing techniques for use in summarizing data for all water supplies in the United States. These data are currently being collected. In addition, all basic-data activities of the USPHS water supply and water pollution control program are being converted to machine tabulating procedures, with some programing for high-speed digital computers.

In changing to machine tabulating methods, certain modifications were introduced that were difficult or impossible to apply with older tabulating procedures. Consequently, the earlier summary data on water supplies in communities of over 25,000 population are often not comparable with the data presented here.

New Concepts

For purposes of this and future reports, two mutually exclusive concepts have been introduced. These are the "community" and the "facility."

A *community* is defined as a political or geographic entity having a water supply to which a census population may be assigned. It is a water-using entity and may be served by one or more water-producing facilities. A community is almost always an incorporated community as listed by the US Census Bureau.

A *facility* is a water-producing entity serving one or a group of commu-

nities. Where treatment is involved, the terms "facility" and "plant" are used interchangeably.

The use of these two concepts permits more cogent data analysis. Many communities receive water from both ground and surface sources, but the percentage of population served by ground sources—at least in the larger communities—is small. By using the "facility" concept, much of this population receiving mixed water can be assigned to either ground or surface sources. The same situation exists with regard to communities receiving both treated and untreated water, although this point is of small consequence in considering the supplies of larger communities. The use of these two concepts also permits comparisons to be made of the percentages of communities within each population group served by organized community water supplies. Although not important to the present study, this comparison is extremely relevant to summaries of small-community practices. The use of the community type of analysis has another advantage in that it permits realistic comparisons between census populations and estimated populations served.

TABLE 1

Distribution of Water Facilities According to Source, Treatment, and Ownership for Communities in the United States With Populations of More Than 25,000—1956

Supply	Communities	
	No.	Per Cent of Total
Source		
Ground	125	22.4
Surface	332	59.4
Ground and surface	102	18.2
Condition		
Treated	539	96.4
Untreated	11	2.0
Treated and untreated	7	1.2
Unknown	2	0.4
Ownership		
Public	439	83.0*
Private	87	16.4*
Public and private	3	0.6*
Unknown	30	

* Percentage of total of those communities for which ownership information is given.

Analysis

This report presents only national summary data and is limited to various items concerning source and treatment, metering, certain treatment details, and needs. Data on water consumption and per capita use are being summarized separately and will be reported later.

Table 1 shows the number of communities served—by sources of water, by treatment practice, and by ownership of the system. Table 2 presents part of these same data on a facility basis and includes estimated populations served. Almost 85,000,000 persons residing in 559 communities of more than 25,000 population each were served by public water supplies from 614 separate facilities. Of the total population served, 75.5 per cent received surface water, 15.5 per cent ground water, and 9.0 per cent mixed water. Slightly less than 1,000,000 persons in this group of communities still receive untreated water; however,

TABLE 2

Facilities for Communities of More Than 25,000 Population According to Source and Treatment Practice—1956

Source or Treatment Status of Water Provided	Number of Facilities	Percentage of Total	Estimated Population Served	Per Cent of Total
Ground	191	31.1	13,115,087	15.5
Surface	367	59.8	63,993,810	75.5
Ground and surface	56	9.1	7,678,348	9.0
Treated	591	96.3	83,712,630	98.7
Untreated	19	3.1	968,965	1.1
Unknown	4	0.6	105,650	0.2

they comprise only 1.1 per cent of those served. All of the population receiving untreated water is served by ground supplies—as shown in Table 5, where data are presented on water treatment by source of supply. For practical purposes, all surface water is treated and 92.0 per cent of the population receiving ground water is receiving treated water. All mixed water supplied is treated.

Of 529 communities reporting, 439 had publicly owned water systems, 87 had privately owned systems, and three reported dual ownership. Data on metering and number of services are shown in Tables 3 and 4. For both tables, only reported cases were used. As might be expected, the percentage of services metered is greater for privately owned than for publicly owned supplies—91.0 and 84.1 per cent, respectively. Almost 84 per cent of water supply facilities for which data were available were more than 90 per cent metered. Data for other percentages are widely scattered and are shown in detail in Table 4. The relationship, if any, existing between per capita water consumption and percentage of metering is being studied separately, as noted previously.

Table 6 presents, in mutually exclusive groups, summary data on the various functional classes of treatment plants. These classes have the standard inventory designations—purification, iron and manganese removal, softening, or any combination of these. Disinfection as a classification is used

TABLE 3

*Services and Meters for Communities of More Than 25,000 Population According to Ownership—1956**

Ownership	Estimated Population Served	Number of Services	Number of Meters	Persons per Service	Per Cent of Services Metered
Public	68,454,395	13,520,185	11,374,686	5.1	84.1
Private	10,504,440	2,443,781	2,224,753	4.3	91.0
Public and Private	962,000	160,000	140,000	6.0	87.5

* Based on those reports in which all data were available.

only if disinfection as a process appears without any of the preceding three classifications. The miscellaneous category includes only those plants which fit none of the above groups—plants which have separately or in combination aeration, sedimentation, chemical dosage, chlorine ammonia treatment, or corrosion control.

"Purification"—either separately or in combination with some other major plant function—generally connotes the presence of slow or rapid filters. In a few instances, plants without filters have been included when so designated by the reporting agency.

Of the total of 591 plants, over half embodied purification as a prime plant function. The largest number of plants and the largest population served—43.6 per cent and 43.8 per cent, respectively, of the total—had purification as the sole function. Disinfection—either separately or in combination with some miscellaneous unit process—comprised 34.5 per cent of the total number of plants and served 37.3 per cent of the estimated population receiving treated water. Various combinations of softening, iron and manganese removal, and purification plants together with four miscellaneous plants comprise the balance of the distribution.

TABLE 4

*Metering and Facilities for Communities of More Than 25,000 Population—1956**

Per Cent of Services Metered	Facilities	
	Number	Per Cent of Total
0	2	0.4
1–10	15	3.1
10–20	14	2.9
20–30	8	1.7
30–40	3	0.6
40–50	3	0.6
50–60	4	0.8
60–70	3	0.6
70–80	5	1.0
80–90	22	4.6
90–99	116	24.0
100	289	59.7

* Based only on those facilities reporting metering data.

Over 82,000,000 persons received disinfected water from 579 plants as shown in Table 7. This is 98.0 per cent of the population receiving treated water and 96.7 per cent of the total population served by water supplies in the group being reported. The latter figure is up only slightly—from 96.1 per cent—from data presented on conditions in 1948 (*6*). About two-thirds

TABLE 5

Population Served by Water Systems With Various Combinations of Source Type and Treatment Practice—for Communities of More Than 25,000 Population—1956

Condition	Surface		Ground		Ground and Surface	
	Est. Pop. Served	% of Total	Est. Pop. Served	% of Total	Est. Pop. Served	% of Total
Untreated			968,965	7.4		
Treated	63,961,910	99.9	12,072,372	92.0	7,678,348	100.0
Unknown	31,900	0.1	73,750	0.6		
Total	63,993,810	100.0	13,115,087	100.0	7,678,348	100.0

TABLE 6

Distribution by Functional Class of Plants Serving Communities of More Than 25,000 Population—1956

Plant Classification	Plants		Estimated Population Served	% of Total Population Served
	Number	Per Cent of Total		
Purification	258	43.6	36,655,894	43.8
Purification and softening	51	8.6	9,043,752	10.8
Purification and iron and manganese removal	7	1.2	438,200	0.5
Purification, softening, and iron and manganese removal	11	1.9	1,375,600	1.6
Softening	16	2.7	1,341,403	1.6
Iron and manganese removal	29	4.9	2,556,779	3.1
Softening and iron and manganese removal	11	1.9	913,613	1.1
Disinfection only	118	20.0	12,579,508	15.0
Disinfection plus another process	86	14.5	18,648,581	22.3
Miscellaneous	4	0.7	159,300	0.2
Total	591	100.0	83,712,630	100.0

of the plants use only liquid chlorine as the disinfecting agent and serve 65.8 per cent of the population receiving disinfected water. The number of persons served by chlorine-ammonia disinfection is 21,700,000, which is considerably less than the almost 29,000,000 persons served in this group in 1948.

Summary data on various other unit processes used in water treatment are presented in Table 8. Gravity rapid sand filters were used in 306 plants serving over 43,500,000 persons and anthracite was used as the filter medium in 43 plants serving 4,700,000 persons. Taste and odor control measures were included in 219 plants serving almost 32,000,000 persons, with activated carbon being used in 171

TABLE 7

Disinfectants Used in Plants Supplying Cities of More Than 25,000 Population—1956

Disinfection Agent	Plants		Estimated Population Served	% of Total Population Served
	Number	Per Cent of Total		
Liquid chlorine	388	67.0	54,025,127	65.8
Chlorine and ammonia	141	24.4	21,729,634	26.5
Hypochlorites	13	2.2	540,695	0.7
Liquid chlorine and hypochlorites	12	2.1	3,044,686	3.7
All others	25	4.3	2,674,268	3.3
Total	579	100.0	82,014,410	100.0

TABLE 8

Treatment Processes in Plants Serving Communities of More Than 25,000 Population—1956

Process	Number of Plants	Estimated Population Served
Filtration		
Rapid sand (gravity)	306	43,516,708
Rapid sand (pressure)	22	2,030,375
Slow sand	25	5,934,248
Anthracite	43	4,752,165
Softening		
Lime soda	81	12,302,055
Cation exchange	10	1,141,700
Aeration	146	19,236,658
*Taste and Odor Control**	219	31,980,462
Activated carbon	171	25,253,530
Chlorine dioxide	35	5,392,029
Others and unreported	44	6,604,256
*Corrosion Control**	216	27,294,543
Phosphate compounds	83	8,093,905
Alkali for pH adjustment	154	20,612,737
Chlorine gas	12	1,181,470
Sodium silicate	7	414,030

* Figures entered under "Taste and Odor Control" and "Corrosion Control" are not additive because of the occurrence of more than one type in one plant.

plants. Some corrosion control was practiced by 216 plants serving more than 27,000,000 persons and aeration was used in 146 plants serving 19,200,000.

Table 9 presents data on chemicals used for coagulation in treatment plants. Alum and lime were the two most commonly used materials, being employed in 300 and 242 plants, respectively.

TABLE 9

Chemicals Used for Coagulation in Facilities Serving Communities of More Than 25,000 Population—1956

Coagulation Agent	Number of Plants	Estimated Population Served
Alum	300	49,883,430
Iron salts	42	9,002,753
Lime	242	40,180,003
Soda ash	66	9,611,990
Activated silica	21	3,673,112
Others	24	2,760,977

Improvements Needed

Improvements currently needed to provide adequate service were reported by 450 facilities. These data are tabulated in Table 10. Multiple needs were listed by many facilities and, consequently, the data are not additive. In addition, the data cannot be quantified in terms of needed construction, because the extent of any need was not defined. The need for improvement is large, however, as only 69 facilities reported no current needs and the remaining 381 facilities reported a total of 1,121 separate needed improvements. About 58 per cent of the total needs were reported in the distribution (distribution-storage-pumping) area, the remainder being included in the source development and treatment areas. Comparisons with data on needs from prior years have not been made because of the lack of quantify-

TABLE 10

Improvements Needed by Facilities in Communities of More Than 25,000 Population—1956

Need	Number of Facilities*
Source, underground	85
Source, surface	85
Transmission	154
Pumping	135
Treatment	158
Distribution	230
Elevated storage	170
Ground storage	104
None	69

* Total of facilities reporting—450—is not additive, because some have more than one need.

ing data and the difficulty in comparing the data from the same community for 2 or more years.

EDITOR'S NOTE: A complete set of tables arranged by population groups and, in some instances, by states is available to interested persons on request from the Chief, Basic Data and Economics Section, Water Supply and Water Pollution Control Program, US Public Health Service, US Dept. of Health, Education and Welfare, Washington, D.C.

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Availability of Fluoridation Chemicals

Joint Discussion

A joint discussion presented on Mar. 28, 1958, at the Illinois Section Meeting, Chicago, Ill.

Cost and Production—*Max C. Metziger*

A paper presented by Max C. Metziger, Director of Research & Development, Blockson Chemical Co., Div. of Olin Mathieson Chemical Corp., Joliet, Ill.

WHEN fluoridation of drinking water was first investigated on an experimental basis, the only chemical that was thought to be suitable and safe to use was sodium fluoride. As a broader fluoridation program was envisaged, however, it was immediately apparent that the supply of sodium fluoride would be inadequate, and that its cost would be too high. In order to be economically feasible the fluoride had to be derived from sources other than hydrofluoric acid and fluorspar. The phosphate industry offered the largest and most economical potential source of fluoride chemicals.

Table 1 shows the relative costs of the fluorides, compared on a fluorine-content basis.

TABLE 1

Cost of Fluoridation Chemicals

Fluoride	Cost *cents per lb*	Fluorine Content *per cent*	Cost of Fluorine *cents per lb*
NaF	13.5	45.2	29.9
Na_2SiF_6	6.5	60.6	10.7
H_2SiF_6*	2.7	18.6	14.5
HF	21.0	95.0	22.1

* 23.5 per cent solution.

Fluorine Evolution

Phosphate rock is essentially fluoroapatite, a complex salt of tricalcium phosphate and calcium fluoride. The average fluorine content of a high-grade rock is approximately 3.5 per cent. Although small as a percentage, this fluoride constitutes an enormous reservoir of potential fluorine because of the large amounts of phosphate rock used in agriculture and industry. In 1957 approximately 15,000,000 tons of phosphate rock were mined, which represents more than 500,000 tons of fluorine. Approximately two-thirds of the rock was used in the manufacture of fertilizer and wet-process phosphoric acid. Hill and Jacobs (*1*) estimated that an average of 27.7 per cent of the fluorine is evolved in the manufacture of fertilizer. Based on this estimate, the amount of fluorine evolved in fertilizer plants is 97,000 tons. Unfortunately, only a small portion of the fluorine evolved is now being recovered, mainly because many of the fertilizer plants are so small that recovery is not economical. According to Hill and Jacobs 53 per cent of the single superphosphate comes from plants

where average production is less than 50,000 tons annually, and only 270 tons or less of fluorine is evolved. The trend, however, in the fertilizer industry is toward higher-analysis products. This requires increasing amounts of triple superphosphate and phosphoric acid. The proportion of fluorine evolution from triple superphosphate operation is considerably higher, because in addition to the den gases a considerable amount of fluorine is evolved during the evaporation of phosphoric acid, which will increase the potentially available by-product fluorine. In Florida alone the total capacity of triple superphosphate has been increased by approximately 1,000,000 tons per year.

It is estimated that in 1958 approximately 35,000 tons of hydrofluosilicic acid will be recovered. Most of this acid is at present converted to sodium silicofluoride and used by the aluminum industry in the production of cryolite. A number of new wet-process phosphoric acid plants have also been put in operation in the middle west in the last 2 years, a possible new source of fluoride chemicals.

Silicon Fluoride Recovery

When phosphate rock is treated with sulfuric acid to form phosphoric acid or superphosphate the fluorine is volatilized largely as silicon fluoride, silica being present as an impurity in the phosphate rock. Two processes are used for recovering silicon fluoride in the phosphate operations:

1. *Recovery in the manufacture of superphosphate fertilizer.* In the manufacture of superphosphate fertilizer, phosphate rock is reacted with sulfuric acid or phosphoric acid to form essentially monocalcium phosphate. The fluorine released as hydrofluoric acid reacts with silica to form silicon tetrafluoride SiF_4. The gases are absorbed in water to form hydrofluosilicic acid in accordance with the following reactions:

$$4HF + SiO_2 \rightarrow SiF_4 + 2H_2O$$

$$3SiF_4 + 2H_2O \rightarrow 2H_2SiF_6 + SiO_2$$

The hydrofluosilicic acid is recirculated until a 15–20 per cent solution is obtained, purified, and evaporated to the desired strength. If the sodium salt is desired, the acid is treated with sodium chloride:

$$H_2SiF_6 + 2NaCl \rightarrow Na_2SiF_6 + 2HCl$$

The sodium silicofluoride is separated by centrifuging, drying, and screening to the desired specification.

2. *Recovery of fluorine from phosphoric acid.* Phosphoric acid is manufactured by the wet process with the following reactions:

$$Ca_3(PO_4)_2 + 3H_2SO_4 \rightarrow 3CaSO_4 + 2H_3PO_4$$

$$2CaF_2 + 2H_2SO_4 + SiO_2 \rightarrow 2CaSO_4 + SiF_4 + 2H_2O$$

In this process most of the fluorine will be found in the phosphoric acid as hydrofluosilicic acid. This can be recovered during evaporation as previously mentioned, but it also can be directly precipitated in the acid as sodium silicofluoride by reacting with Na_2CO_3.

The process normally used in the sodium phosphate industry is:

$$H_2SiF_6 + Na_2CO_3 \rightarrow Na_2SiF_6 + CO_2 + H_2O$$

The solids are separated by centrifuging, drying, and screening. In this

process from 50 to 75 per cent of the fluorine can be economically recovered as sodium silicofluoride. Hydrofluosilicic acid cannot be recovered as such, because it cannot be separated from the phosphoric acid by any practical means.

Uses and Production

There are a number of established uses for sodium silicofluoride. The supply of this product is, therefore, influenced by market conditions in certain industries. Some of the most important applications of sodium silicofluoride are: fluoridation of municipal water supplies, laundry sour, opacifier in glass manufacturing, vitreous enamel, beryllium and zirconium metallurgy, bactericide, fungicide, insecticide, termite control, preservative, mothproofing agent, and gelling agent in the manufacture of foam rubber.

TABLE 2

*Fluorine Production**

Year	Production—*long tons*		
	Na_2SiF_6	NaF	HF
1951	15,636	6,122	43,660
1952	12,686	3,992	41,512
1953	16,816	5,401	51,845
1954	19,783	4,721	54,968
1955	19,928	5,871	66,637
1956	20,456	5,798	75,500
1957†	—	—	77,417

* Source of this table is Ref. *3*.
† Eleven months.

Consumption of fluoride chemicals in water fluoridation was estimated (*2*) for 1957 to be:

Fluoride	*tons*
Sodium silicofluoride	8,000–10,000
Fluosilicic acid, 25 per cent	7,000– 8,000
Sodium fluoride	1,500– 1,600

Production of the fluorine chemicals that are normally reported to the US Bureau of Census are summarized in Table 2.

The phosphate industry is now and will continue to be the main source of fluorine chemicals for use in water fluoridation. Only a small fraction of the available fluorine is now being recovered, but recovery is steadily increasing. This is due mainly to increase in size of production plants, the expanding triple superphosphate industry, and the increasing use of phosphoric acid in fertilizer manufacture. The quantities of fluorine available in the phosphate industry are very large, but more technological developments are needed to prevent waste of this important natural resource.

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Need for Increased Supplies—*Oscar Gullans*

A paper presented by Oscar Gullans, Chief Water Chem. Engr., South Dist. Filtration Plant, Chicago, Ill.

The increasing use of fluorides in water treatment, along with the increased demands for fluorides by the chemical and aluminum industries, has recently given reason for concern for future requirements of this material. The city of Chicago has not been able to obtain sufficient hydrofluosilicic acid for its current needs in the water fluoridation program. Contracts for 1958 indicate that the supply will be less than it was in 1957, when the city was able to obtain only 60 per cent of its requirements.

Present and Future Requirements

A look at the current fluorspar market (*1*) reveals the following: of the fluorspar production in 1957, 270,000 tons went into steel production, 110,000 to aluminum, 210,000 to chemicals, and about 70,000 tons to ceramics; the federal government purchased about 230,000 tons for stockpiling. Of the total requirements, domestic sources supplied 325,000 tons and some 620,000 tons came from abroad, two-thirds from Mexico, and the rest from Spain, Germany, Canada, and Italy.

With the increasing use of fluorides by the chemical and aluminum industries, it is estimated that they will require an additional 150,000 tons by 1965. Market projections also indicate that other consumption of fluorine chemicals, much of which will go into atomic power projects, will require a further increase of 305,000 tons per year.

New Sources

With limited supplies and reserves available (35,000,000 tons) consumers are beginning to wonder how long supplies will last, and producers are beginning to examine the possibilities of phosphate rock. Since the only commercially worked deposit of natural cryolite is on the island of Greenland, some aluminum producers are making synthetic cryolite in order to decrease their dependence on the use of imported material.

The possibility of obtaining larger supplies of fluorine from phosphate rock processors seems to be the best solution. The rock processors scrub hydrofluoric and hydrofluosilicic acids from their waste gases, and throw most of them away. Processors are now becoming interested in ways of changing this waste to profit. At the present time they cannot compete with fluorspar, either domestic or imported. If the demand for fluorspar increases as predicted, however, a combination of increased prices and improved technology to reduce recovery costs will permit the rock processor to enter the market.

It has been predicted that almost all of the fluorine for the chemical and aluminum industries (substituting for 500,000 tons as fluorspar) will someday be recovered from phosphate rock, rather than from fluorspar. This development may take place within anywhere from 5 to 25 years.

Shortages

Aluminum companies are now contracting with phosphate-rock processors to buy waste silicofluorides from which they can make synthetic cryolite or aluminum fluoride, to be used in their reduction-process baths. Under a new process it takes about 75,000 tons of cryolite to produce 1,000,000 tons of aluminum. One large aluminum producer recently contracted for 12,000 tons of hydrofluosilicic acid, 100 per cent basis, in any concentration from a 5.10 to a 30 per cent solution. This is equivalent to withdrawing 48,000 tons of hydrofluosilicic acid, 25 per cent basis, from the available market in a single year. Further demands of this kind can be expected, as a consequence of the expansion of aluminum production. With most of the fluorine from phosphate rock processors going to the chemical and aluminum industries, the chances of obtaining hydrofluoric or fluosilicic acid for water treatment will rapidly become smaller and smaller.

From this, it is easy to see why Chicago has had difficulties in getting its annual requirement of 7,500 tons of hydrofluosilicic acid, 25 per cent strength. The city obtained about 2,450 tons for use at the South District filtration fluoridation stations in 1957 (*2*), which was almost the plant's annual requirement, but the Central and North District plants were only able to obtain 2,700 tons, an average of 60 per cent of their total requirements. The total amount available to the city on 1958 contracts is 3,550 tons, of which 2,000 tons is allocated to the South District Plant. This is considerably less than the amount supplied in 1957, and only a little over 50 per cent of the city's current requirements. Chicago will, therefore, be required to look to other sources for sufficient material to carry out its fluoridation program. Since sodium silicofluoride seems to be more readily available, and is the cheapest of the three water fluoridation chemicals, the South District Plant is now experimenting with the possible use of this material. As soon as the equipment can be installed for handling, all of the hydrofluosilicic acid that is available to Chicago will be diverted to the North and Central Districts. It is hoped that the supply of the sodium silicofluoride will remain available for the city's needs.

It has been recommended that the present limits of 98 per cent purity for sodium silicofluoride be reduced to 95 per cent, in order to have more of this chemical available. There is a considerable quantity of 95 per cent material from the Florida rock processors. The additional 3 per cent contamination consists of small amounts of gypsum, calcium fluosilicate, and phosphates, all of which are fairly soluble in low concentration. Laboratory tests indicate that the presence of these impurities improves the solubility of the fluoride. It is expected that the price for such material would be prorated with the current price of 98 per cent material now being supplied. This added supply, together with possible increased production of higher grade sodium silicofluoride, can probably be used to supplement the withdrawal of the hydrofluosilicic acid from the market in the southeastern area of the United States.

Imported Supplies

There has been some increase in imports of the silicofluorides from Holland and Japan. These imports

have been of varying quality, and great care must be exercised in applying specifications that will guarantee the user a product of good feedability. Some of these materials have been used largely in Canada and in a few eastern cities where they can be delivered by ocean freighters. Samples of these materials indicate that they are of a fine crystalline structure, and yet are free from fines, which makes them readily feedable and free-flowing. One plant superintendent claims that it is cheaper to buy this material, which is shipped 3,000 mi by boat, than to ship the same material 300 mi by truck or rail. American processes of manufacturing sodium silicofluoride do not readily lend themselves to the manufacture of the crystalline material without considerable added cost.

Experiments

With these considerations in mind, Chicago water utilities are experimenting with the pelletized silicofluoride developed by a local manufacturer to see if it can be adapted to a simple feeding system. In addition to the use of saturator tanks, where water is percolated through 10 ft of pellets, the city is trying certain additives to the water to increase the material's solubility and cut down the amount of water required. Sodium silicofluoride is only slightly soluble in water, and it takes about 35 gal of water to dissolve 1 lb of the fluoride at ordinary temperatures. Solubility is better with warm water, but then there is the added cost of heating the water. A weak solution of aluminum sulfate (7½ per cent solution) shows promise of being the best additive for dissolving the silicofluoride.

Chicago is also planning experiments with other compounds that may be readily adaptable for helping to dissolve the material. Experiments in dissolving the finely powdered silicofluoride were not successful, due to a carry-over of the finer materials even at low up-flow rates in a saturator tank. It has also been learned that attempts to dissolve the powdered or pelletized material with fairly hard water, 170–255 ppm hardness, were not successful, due to the formation of a coating of calcium fluoride on the granules or pellets which rendered them almost insoluble. As soon as these experiments are completed the results will be published.

The Chicago water utilities have also tried experimentally to dissolve finely powdered fluorspar, available from mines in southern Illinois, with various concentrations of aluminum sulfate solutions, by a method recently published. The material will dissolve rather slowly, and the amount of stirring and dissolving equipment that would be required to supply the amount of fluorine needed would run the cost above that for silicofluoride. There is a type of fluorspar being imported from Mexico which lends itself more readily to this dissolving method, but the freight rates to Chicago might make the cost prohibitive.

Recommendations

In addition to the current study on availability of fluorides being made by AWWA it would be well for some federal agency to investigate the current fluoride market, and the future availability of these materials. Often, only 50 per cent of Chicago's requirements are available, and there is no alternative but to turn to other types of material. It becomes a rather frustrating situation when a considerable sum of

money is spent for equipment only to find at the end of 2 years that the equipment is obsolete because that particular type of fluoride is no longer available. Perhaps some type of allocation system should be adopted, similar to that for chlorine during World War II, to assure the water utility industry its share of this essential chemical. Permission to contract for these materials on a 2-, 3-, or 5-year basis instead of a 1-year basis might give the supplier and the user a little more security.

A large midwestern city, currently considering the use of fluosilicic acid, is investigating other sources of fluorides in anticipation of a dwindling acid supply. Chicago will also be asked to recommend the type of fluoride equipment to be installed in its new Central District Filtration Plant within the next year. Current investigations in the best material to use, its availability, and a simplified method of processing and feeding the material will, therefore, be given top priority. Any suggestions or ideas on new methods of processing or feeding fluoridation chemicals, in order that Chicago's fluoridation program may be continued, will be welcome.

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Survey of Fluoride Availability

Staff Report

AT the request of a prominent water utility official, who was experiencing difficulty obtaining a continuous and adequate supply of fluosilicic acid, AWWA surveyed the manufacturers and jobbers to learn the status of the supply of this chemical as of: [1] Mar. 1, 1958, [2] Jul. 1, 1958 and [3] Jan. 1, 1959. The questionnaire, mailed on Feb. 25, 1958, was enlarged to include sodium fluoride and sodium silicofluoride. The questionnaire was sent to a total of 34 companies and answers were received from 22. The questionnaire consisted of only three questions:

1. What is the status of the availability of fluoride chemicals used in water supplies?
2. Is your company a manufacturer or a jobber of these chemicals?
3. Are you an importer?

Status of Supply

Question 1 requested the status of the supply of the three chemicals. It asked if each of the chemicals was in "Ample" or in "Short" supply.

Ample. Ample was defined as a sufficient supply of the chemical in stock or available to permit the supplier to fill orders from established customers promptly and to accept and fill new orders promptly.

Short. Short was defined as a supply which would not permit the prompt filling of the requirements of old customers or the acceptance of orders from new customers for prompt delivery.

Table 1 gives the results of this survey.

The data in Table 1 lead to the following conclusions: sodium fluoride, supply ample; sodium silicofluoride, supply ample; fluosilicic acid, *supply critical.*

Manufacturers' Comments

Comments made by four manufacturers of fluosilicic acid, to explain the reasons for the critical supply, should be noted:

Manufacturer 1. Material is available for customers with whom we have contracts, and we have been taking on some additional small accounts. We have plants at which this material could be made available, but, due to the capital expenditure required, it is necessary that we have a 3- or 5-year contract before we would feel justified in putting in the necessary equipment.

Manufacturer 2. If there is a shortage of fluosilicic acid, it probably stems from the fact that most water works buy on a short-term basis. It takes a considerable investment to install facilities to filter and concentrate the weak acid to a grade suitable for fluoridation. Unlike sodium silicofluoride and sodium fluoride there is no industrial market for this acid, except a special one in Florida. Consequently, companies generally might hesitate to make the investment to produce acceptable acid on the basis of a 1-year contract, since they would not be sure of an outlet after the first year.

My guess is that water works desiring to use fluosilicic acid can find adequate

sources of supply if they can find a way to make at least their initial contracts for a period longer than a year.

Manufacturer 3. At present, there is a shortage of the acid. The main reason unquestionably is that producers who would be in a position to recover the acid in their operations have been rather reluctant to spend the money on the necessary equipment. This equipment is very expensive and, therefore, could only be installed profitably if the producers would have the assurance of continued business.

TABLE 1

Status of Fluoride Supply

Fluoride	Status of Supply, as of	Answer	
		Ample	Short
Sodium fluoride	Mar. 1, 1958	11	0
	Jul. 1, 1958	10	1*
	Jan. 1, 1959	9	1*
Sodium silicofluoride	Mar. 1, 1958	15	1
	Jul. 1, 1958	14	1*
	Jan. 1, 1959	13	1*
Fluosilicic acid	Mar. 1, 1958	6†	2
	Jul. 1, 1958	6†	2‡
	Jan. 1, 1959	5	3§

* Questionable.
† One supplier states that he is prepared only to accept additional orders in 50-gal quantities. A second supplier will accept additional orders from small communities.
‡ One supplier states that, due to seasonal cycles, he will probably be in short supply at midyear.
§ Two questionable.

You are probably aware of the fact that, unfortunately, the bulk of the municipalities are buying their material on a spot basis against public bids or, in some cases, against yearly contracts. A large percentage of these municipalities, according to their regulations, will give the business to the lowest bidder regardless of how much their interests may be effected. By staying with one supplier, the municipality would have a reasonable assurance of obtaining a continuous supply.

A certain number of producers who produce the acid, or could produce it, feel that their interests would not be protected sufficiently by going through the expense on equipment without a certain amount of assurance that they will continue holding this type of business for a number of years. We believe, in all sincerity, that if some of the large municipalities would agree to contract for this material on a, let's say, 3-year basis, some of the producers would be more than willing to extend their facilities.

Manufacturer 4. A few remarks are necessary regarding our position on fluosilicic acid. We produce fluosilicic acid in a number of our plants but it is all either captive or under contract for industrial use on a "when available" basis. Considerable advance preparation would be necessary for us to offer fluosilicic acid for water fluoridation from any given plant. We would have to install purification equipment and make arrangements for transportation by tank truck. We are not particularly interested in small-package business and feel that the additional cost involved in packaging the acid would overprice it in comparison with the dry fluorides, particularly sodium silicofluoride.

Thus, a typical situation in which we might consider taking on fluosilicic acid would be where we were approached by a large city, close to one of our manufacturing plants, which would give us 3–6 months to get ready, and then some reasonable assurance that we could continue to keep the business.

If some cities are having trouble obtaining supplies of fluosilicic acid, perhaps they are running into somewhat the same conditions with other prospective suppliers. The obvious answer to the problem is that it is much more important to arrange well in advance for supplies of fluosilicic acid than it is with the dry fluorides, which can be supplied readily from stock by most producers.

Summary

This fluoride survey indicates that ample stocks of both sodium fluoride and sodium silicofluoride are available at present and for the immediate future.

Fluosilicic acid is in critical supply, at present, and may continue to be so in the near future. Only for small users does the supply seem to be ample. The present consensus of manufacturers appears to be that an ample supply of the acid can be made available for large users also, if the contracts for the acid are for a long enough time to safeguard the investment in additional plant which would be required to manufacture the acid. Since most, if not all, municipalities are limited by law or regulation on the length of contracts they enter into, it appears that either a compromise is needed or some other source of fluoride must be sought.

'Do It Now' Campaign Under Way

A "Do It Now" campaign aimed at helping to counteract the slowdown in the nation's economy, as well as to put public water systems in shape to provide improved water service adequate to meet the growing needs of each community, appears to be paying off to the tune of a 20 per cent increase in 1958 scheduled water works construction. A survey covering 180 communities serving about 15 per cent of the population that has public water supply indicated that 54 per cent were speeding up projects scheduled for this year and 23 per cent were moving up projects originally scheduled for 1959. This represented the speedup of $59,000,000 worth of construction.

Launched at the Dallas Conference in April, the campaign was triggered by a telegram to President Eisenhower and a letter to the governor of each state, asking their help in stimulating each local community to speed up action on needed construction. In Missouri, Governor Blair responded by declaring June "Water Works Month." In other states, action was taken through public officials directly involved with public supply matters. And the indicated result was that overall expenditures for 1958 would be 120 per cent of those originally planned. This rate of construction would push the 1958 total above the $560,000,000 level of last year, behind which it was lagging approximately 20 per cent in the first quarter of the year.

AWWA expects to continue its efforts to promote this shot in the arm to the nation's economy. Such a program ties in directly with the Association's present major effort to lead the water industry in correcting basic water system deficiencies that were a direct result of war shortages of material or the inflated costs of postwar expansion. It is the industry's goal to provide its customers "all the water they need, when and where they need it"—a goal which it now has the plans, but not yet the public support, to achieve.

Value, Organization, and Implementation of Water Utility Safety Programs

Panel Discussion

A panel discussion presented on Apr. 23, 1958, at the Annual Conference, Dallas, Tex.

Value of a Safety Program—*Arthur J. Webb*

A paper presented by Arthur J. Webb, Safety Coordinator, East Bay Munic. Utility Dist., Oakland, Calif.

WATER utility employees trust their supervisors to know enough about their job to keep them out of dangerous places. They expect the supervisor to give them safe jobs to do, or the proper instructions so they can do a dangerous job safely. The supervisor, on the other hand, expects his men to know all there is to know about their jobs, especially if they are old-time employees. In reality, supervisors do not know enough, and neither do their men. This fact is reflected in the poor safety record the water utilities have, compared to other utilities. Table 1 compares the accident rate of water utilities with those of three other types of utility.

TABLE 1

Comparison of Utility Injury Records in 1956

Utility	Frequency Rate*
Communications	0.99
Electric	6.84
Gas	8.68
Water	15.58

* Frequency is the number of lost-time injuries per 1,000,000 man-hr (500 men working 1 year equal 1,000,000 man-hr).

Insurance Savings and Refunds

Aside from the death and injury which it may prevent, a safety program may result in large savings in operating costs.

One of the easiest ways of saving money with a safety program is through the insurance dollar. This can be demonstrated, and should be of interest to the business manager. First of all, the insurance rate for a company is determined by the experience rate of the industry. As the industry lowers its number of injuries, the insurance rate will fall for all companies, regardless of whether they have an injury-prevention program. This only operates at the level of a state, which regulates the compensation rates for various industries.

Not all the insurance rates are absolutely set by state law, however. If a company's experience is bad enough, the insurance company can either raise the rate above the basic rate set by the state or cancel the insurance altogether. In 1949 the East Bay Municipal Utility District paid 125 per cent of the

TABLE 2

Premium Savings, 1949–1957

Year	Premium	EBMUD Base Rate *per cent*	100 Per Cent Base Rate
1949	$ 64,172.67	125	$ 64,172.67
1950	58,595.04	115	58,595.04
1951	49,837.56	86	57,950.65
1952	43,561.96	69	63,133.27
1953	65,179.61	82	79,487.32
1954	75,935.57	92	82,538.66
1955	66,134.26	89	74,308.15
1956	54,995.78	71	77,458.84
1957	47,203.15	71	66,483.30
Totals	$525,615.60		$624,127.90

Total Premium at 100% Base Rate:	$624,127.90
Actual Rated Cost:	525,615.60
Saved:	$ 98,512.30

basic rate, but in 1957 paid only 71 per cent.

To compute a rate, the insurance company will average previous 3-year accident costs and frequency, and then consider whether the company has a planned program to reduce injuries. Then it will set the next year's rate from that pattern. For each bad year, the deaths or amputations will reflect over a 3-year period in the insurance rate. A good record, of course, will also reflect for a 3-year period. This can be an important business consideration. Table 2 shows the East Bay District's premium savings for the period 1949–1957.

Some insurance companies have a refund system. In California the State Compensation Insurance Fund will review the record at the end of the year and make a refund based on the percentage by which the company was able to keep actual costs below the premium it had been assessed during the year.

The East Bay District has been able to recover more than $269,000 between 1949 and 1957 in direct cash refunds because of reduced injuries. (This figure includes estimated and incomplete refunds for 1956 and 1957.)

Uninsured Losses

The figures given by the National Safety Council and the US Bureau of Labor Statistics claim that for every $1 compensation cost there are 4–7 uninsurable dollars lost. These are direct costs to a company.

Some of the uninsured costs of a small injury, say one involving $5 in medical costs, might be:

1. In every injury, however small, there will be observers, people who had to help the injured party, describe the injury to other employees, and lose time in other ways.

2. The supervisor's time will be lost in helping the injured man, home calls, doctor visit, insurance interviews, telephone calls within the company, reports, investigations, and related duties.

3. If an employee is injured during the day, it is common practice to pay him for the whole day.

4. Often the loss of time in a day due to injury causes the crew, or part of it, to work overtime.

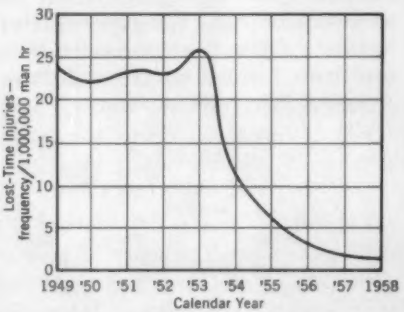

Fig. 1. Frequency of Injuries

The East Bay Municipal Utility District safety program has reduced the accident frequency from more than 20 to 1.71.

5. There may be decreased production from the man who was injured when he returns to work.

6. A new man may have to be trained to take over the injured man's job, temporarily.

7. There will be clerical costs for processing report forms through the insurance company and the accounting department.

8. There may have to be repairs to equipment damaged in an accident.

9. It may be necessary to pay rental costs for equipment while repairs are made to the damaged equipment.

10. There may be liability costs for damages to property of others.

TABLE 3

Action Levels of the East Bay Safety Program

Level	Action
Learning the facts	1. Eye tests 2. First aid records 3. Accident reports 4. Monthly medical statistics 5. Conferences
Teaching the facts	1. Films 2. Pamphlets 3. Publication of accident statistics 4. Driving tests 5. Interviews with new employees 6. Safety manual 7. Pipeline conferences 8. Supervisor training
Awareness and teamwork	1. Contests 2. Recognition for good records 3. Publication of investigation results 4. Safety club 5. An excellent medical program

East Bay Safety Program

The East Bay District wishes to make safety a way of life. Its entire safety program operates through the foremen and the men. The utility merely coordinates their efforts and stimulates the program. Table 3 shows how the program is implemented at different levels.

Any utility may institute a similar program (*2*). By means of its safety program the East Bay District has reduced its rate of frequency of injuries from more than 20 lost-time accidents per 1,000,000 man-hr in 1949 to 1.71 in 1957 (Fig. 1). The national average in 1956 was 15.58 (*1*).

Summary

Accident prevention is cost control. The cost of accidents in dollars and the human factors have been discussed. The savings in direct cash from insurance savings and reduction of uninsurable losses have also been described. Any utility may take its own insurance premium, cut it in half, multiply that saving by four or six, and arrive at a very appreciable operating economy. If this saving were put into a trust fund, the safety division could soon be financed by the interest produced. The program would no longer cost money and could be saving progressively larger amounts of money each year. To this may be added the morale factor and the public relations value. All of this proves that a safety program pays off.

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Safety Program for Shops, Stores, and Offices

James E. Hickman

A paper presented by James E. Hickman, Safety Engr., Dept. of Water & Power, Los Angeles, Calif.

A safety program should be carefully planned to fit the needs of the company. When the program gets under way the results are often not immediately apparent, but if the program is well-planned improvement should be steady, although there may not be any single spectacular drop in accident frequency. A "crash" safety program, although it may bring some immediate results, often bogs down and loses its effectiveness, which may lead to an apathetic employee attitude toward safety.

Essentials

Nearly every safety textbook states that a safety program needs the support and backing of top management. This is true, but, in addition, it needs direct executive leadership. One large water utility showed almost miraculous improvement when its executive took a position of leadership in the safety program. Even though they previously were in favor of a safety program there was some doubt in the minds of nearly all levels of supervision as to how far they should go in putting forth efforts toward improving their safety performance. When the top levels of management assumed active leadership of the program, this doubt disappeared and improvement started almost immediately.

The first requisite, therefore, is leadership from the top right on down to the first-line supervisor, who is a vital part of management. While the success of a safety program depends on supervisory capacities at all levels, it rests to a greater degree on the first-line supervisors, who are directly responsible for the application of the safety policy of management.

The second essential is to organize and promote the participation and interest of every employee in the program, in order to instill a safety-conscious attitude, rather than depend upon enforcement of rules and regulations.

The third essential is a general survey of plant conditions and processes, together with an analysis of previous accidents, in order to learn the necessary facts to develop an effective program for preventive action.

Implementation

Whether the safety program is coordinated by a full-time safety engineer or by a member of the staff who also has other duties, certain plans should be made to promote the effectiveness of the program. One of these is a good system of investigating, reporting, and recording accidents. In addition, a method should be organized to receive information from other safety organizations and from the agencies engaged in forwarding the safety movement, for example, the accident-prevention committee of AWWA (*1*) and the National Safety Council (*2, 3, 4*). The safety section should be in close contact with the medical division or the doctor who handles compensation cases for the utility concerned. In short, there should be an inflow and outflow

of information through the office handling the program. All information and facts pertaining to safety should be available and passed on to employees down the line.

One very effective part of a safety program is the establishment of safety committees. There are two types of committee used by many companies: a supervisory safety committee, and a committee composed of workers. The supervisory committee is the most important, because it can make decisions and report findings to a higher level of supervision. This makes safety a regular function of the line organization and eliminates many long delays between a recommendation and its being put into effect. By appointing members with poor safety records as well as those with good records, it has been observed that service on the committee will tend to improve the performance of those who previously may have shown little or no interest in the safety program.

It is well to provide some guidance for the committees, preferably through the safety engineer or a second-level supervisor. This is desirable because committees will sometimes tend to get off the track into areas which are not fruitful in preventing accidents. One committee in a large company dwelt at considerable length on the possibility of replacing a rather antiquated crane. Although this crane was slow and unhandy, there had never been an accident caused by it, nor was there likely to be one if it remained in service. A new crane would have made the operation more convenient but not necessarily safer. More than 80 per cent of disabling injuries are the result of unsafe acts of persons, and less than 20 per cent are due to unsafe equipment. Committees should, therefore, spend time and effort commensurate with these figures. Companies which have established safety committees have almost unanimously agreed that they have achieved concrete results and that these committees operate equally well in shops, offices, or field areas.

Another valuable safety tool is the foreman's safety meeting, which is particularly effective because it reaches all employees. The meetings are usually held weekly, the foreman meeting on the job with his men, and presenting a short talk on safety subjects that concern his group. These meetings offer a good opportunity to discuss accidents, or near misses that may not have resulted in injury but if allowed to recur could injure someone.

Useful material can be obtained from the National Safety Council, Chicago, Ill., in the form of booklets containing about 50 short talks for foremen. The company may also prepare its own talks. This is desirable, because it is then possible to include problems applicable to the individual company.

Inauguration of a program for training the new employee in safety practices is a must. This takes little time and amply repays the efforts spent. Particular attention should be paid to insure that the new employee is familiar with the proper and safe operation of shop and material-handling equipment. To assume that a new employee knows the safety practices required by the organization often results in injuries whose cost is many times that of a regular period of instruction and indoctrination.

All sections should investigate their accidents. This can be included in the committee's duties or can be delegated to the first-level foreman concerned.

Unless the cause or causes of accidents are determined, the company is not in a position to know what to do to prevent their recurrence. The more thorough the effort in fact-finding concerning each accident the less chance of recurrence, and if the information gained is widely disseminated all concerned will know how it happened and how prevention can be effected. If this phase of the program is neglected employees may soon take the attitude that serious accidents often cannot be prevented.

First-aid training is another tool for the safety program, primarily because it develops confidence to deal with emergencies when they arise. Another value of first-aid training is that it develops the employee's safety consciousness. Use of first aid could prevent a fatality and often prevents minor injuries from becoming serious by preventing infections. The first-aid course sharpens the desire for safety, shows that accidents can be prevented, and focuses attention upon many specific ways to avoid accidents. In short, Red Cross first-aid instruction (*5*) might be called a basic accident-prevention course, because it stresses the cause and prevention of injuries as well as first-aid treatment.

Another worthwhile activity, which offers opportunity for employee participation, is regular inspection of the work areas. This permits early discovery of unsafe conditions and actions. An important value of inspections is that supervisors and workers knowing that inspections are going to be made regularly will strive to eliminate unfavorable conditions which they may observe. If employees take part in investigations and inspections to find and correct the causes of accidents, employees and supervisors will become better acquainted with accident prevention, and will be able to make valuable recommendations.

Shop Safety

Shop work in a water system is never really routine. Rush jobs resulting from breakdown of equipment or shutdown of facilities frequently occur. In performing shop operations it takes only a little additional effort to develop a completely well-rounded program.

The shop safety program should devote considerable attention to: [1] housekeeping, [2] material handling, [3] machine guarding, [4] equipment for hoisting, [5] hand and power tools, [6] first aid, [7] fire prevention, and [8] field safety. The unsafe practices involved and the unsafe conditions discovered should be borne in mind.

1. Good housekeeping is a definite aid in accident prevention. By maintaining clean and orderly work areas accidents such as slips or falls caused by a spot of oil, a rolling pipe, a protruding board, or an obstruction in an aisle or on a stairway are eliminated. These accidents often get little attention, as they are not spectacular, but in California industry alone, slips and falls are responsible for more than 20,000 disabling injuries yearly. Good housekeeping would have prevented most of these injuries. If aisles and storage places are clearly marked and are kept free from loose material, accident frequency is automatically lowered. The time and effort spent on good housekeeping and maintenance will always return benefits, not only in reducing accidents, but in increasing production and creating in a shop a

better and a more pleasant atmosphere in which to work.

Many supervisors become concerned at the prospect of the start of a safety program, fearing that production will be curtailed. Actually, safety and production go hand in hand, and good production is impossible without safety. Most companies are pleasantly surprised to see an increase in production and efficiency plus a boost in employee morale as a result of adopting an effective safety program.

2. Nearly everyone handles materials in some form, and in a water system shop, people are continually being called upon to handle heavy, oddly shaped, awkward objects. It pays dividends to provide adequate methods to handle material, from a standpoint of both efficiency and accident prevention. For example, in a shop where a shortage of hand trucks exists, the time lost by employees searching for one to move material can run far in excess of the cost of providing adequate equipment.

3. Effective machine guarding is a must, because injuries from machines produce a high percentage of totally disabling injuries. Machines should be adequately guarded, and newly purchased machinery should conform to the shop's safety requirements. If the engineering and purchasing divisions will insist on this it will insure a continuous program of machine guarding.

4. Hoisting equipment, because of its dependability and necessity, is often not given its share of attention in a safety program. Hoisting accidents, while happening infrequently, usually result in serious injuries or fatalities, or in damaged equipment or material even when no injury to personnel occurs. A shop should have a regular schedule of inspection of hoisting equipment, which should include slings and fittings. New employees should be instructed in the safe use of the equipment.

5. Hand and power tools are frequent producers of injuries which can be prevented. Inferior tools should not be tolerated in any shop. The tool room should be equipped to repair small tools and the supervisor should be certain that men under his jurisdiction do not use faulty tools. Any unsafe tool should be removed from service immediately. Electric tools should be regularly inspected for unsafe operation. These inspections should be extended to cover bench grinders, buffers, and all electric- or air-powered tools. Ladders should be regularly inspected and every effort should be made to purchase ladders that meet the requirements of the American Standards Association (*6*).

6. First aid facilities should be provided. A good safety program should try to eliminate the untrained "shop doctor." Someone trained in American Red ross first aid should treat minor injuries, and he should never exceed his capabilities. The shop should have an organized plan for handling serious injuries, one that can be put into action immediately to summon professional help, an ambulance, or a rescue unit if needed.

7. Fire prevention is an often-neglected phase of a safety program. The death or injury of an employee or damage to buildings and equipment due to fire are just as preventable as any other type of accident. Formation of a company fire brigade is another area where employees can participate to good advantage. Fire is an ever-present danger which should be recognized as such. Local fire depart-

ments are usually anxious to help set up a fire-prevention program.

8. A water system shop normally has a certain number of people working in the field on maintenance or repair jobs. Field employees should be provided with first-rate equipment, and they should be visited regularly to insure that they are observing the safety practices required to maintain a steady downward trend in accident frequency.

The aforementioned particulars of shop safety are not to be considered as complete, but rather as minimum standards in these areas of operation. These things are keystones of a successful and vigorous shop-safety program.

Warehouse and Office Safety

In the warehouse or stores section the majority of injuries are to the hands, feet, and back. Here it is essential to start a training program to bring about the best methods of lifting, handling, and storing materials by manual or mechanical means. Again the safer method is consistently the more efficient and faster way to handle material.

Office safety, while apparently going unnoticed in many companies, is often a producer of injuries, though not in as great a number as some other departments. One office injury in California a few years ago resulted in death, and cost the employer more than $75,000 in compensation and related costs. Often the causes of office accidents can be traced to poor layout of the office or structural characteristics of the building, particularly elevators, stairways, doorways, or uneven floor levels. Office committees are invaluable in helping resolve safety problems for their group. They usually are not required to meet as often as other safety committees.

In a good program there are hundreds of ways to help the program along. Interest in setting a safety record without accidents, friendly rivalry between groups to make a good showing, individual or group recognition, these are all valuable aids in an effective program.

As long as leadership, participation, investigation, inspections, and training are maintained a safety program will move forward toward the ultimate goal, zero accident frequency.

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Safety in Chicago's Construction Activities

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The Department of Water and Sewers of the city of Chicago was established in 1953, as the result of reorganization. Since that time its management has been vitally interested in safety engineering and the field of accident prevention in water utility operations. This department has installed an accident reporting and recording system which provides for reports to the US Department of Labor, the National Safety Council, and AWWA.

The department is divided into the Bureau of Water and the Bureau of Sewers. The former, employing over 2,600 persons, consists of five operating divisions: [1] collection, [2] distribution, [3] meters, [4] pumping station operations, and [5] purification. These five divisions function as an integrated water utility.

This article will discuss the safety activities of the distribution division, which is responsible for the engineering, design, construction, and maintenance of the distribution system. These operations require the employment of over 1,500 persons, and the use of a great variety of equipment, machinery, and vehicles.

Accident Data

In 1957 the employees of the distribution division (*1*) were assigned as shown in Table 4.

The standard method of judging the safety performance of any organization by the National Safety Council or the US Department of Labor is based on the organization's [1] frequency rate and [2] severity rate. The AWWA has established the frequency rate as the criterion by which safety performance and progress are recorded and compared.

1. Frequency rate is the number of employee-disabling accident injuries per 1,000,000 man-hr worked.

2. Severity rate is the number of lost-time days due to employee disabling accident injuries per 1,000,000 man hr worked.

For the year 1957 the distribution division had an accident frequency of 9.49 and a severity of 452. This appears to be a good record when compared to the National Safety Council's report of water utilities (*2*) for 1954–1956: 3-year average frequency rate, 16.10; severity rate, 673. Unfortunately, for 1957 the distribution division had 23 of the total of 29 disabling accident injuries within three sections employing 791 of the total 1,515 persons. The frequency rates of these sections varied from 10.08 to 19.25, and severity rates from 516 to 811.

TABLE 4

Distribution of Utility Employees

Work Classification	No. of Employees
Engineering planning and layout	80
Waterline construction	478
Waterline maintenance	734
Meters, installation and inspection	44
Administration and clerical	155
Janitors and watchmen	14
Truck service to other divisions	10
Total	1,515

Table 5 shows the division's accident injury data for 4 years of the formal safety program, and illustrates the progress made by the end of 1957.

The data in Table 5 disclose that a total of 700 nondisabling accident injuries have been reported and recorded by the division. This includes first-aid medical services and cases requiring primary and subsequent medical treatment with no lost time. Employees were sent to the city physician, or to listed physicians and hospitals, for medical examination when an accident injury was claimed, and rejected cases are not included in the statistics. For the same period, 142 disabling accident injuries and 108 of 142 disabling injuries in the period 1954–1957. The construction forces incurred 69 of the disabling accident injuries, while for the same period the maintenance forces reported 39 disabling cases. Also, the average of 914 district employees (58 per cent of the average total of 1,564) had 78 per cent of the nondisabling and 76 per cent of the disabling injuries, for the time of operation of the safety program. This evidence of the area of the greatest work hazards, presented so conclusively, confirms an analysis made in 1953 and supports the conclusions of administrators and supervisors, revealed in their deliberations and the planning of the department's safety program.

TABLE 5

Accident-Injury Data

Item	Year				Average
	1954	1955	1956	1957	
Nondisabling injuries	191	205	168	136	175.0
Disabling injuries	38	37	38	29	35.5
Time lost, days	1690	1358	7572	1380	3000.0
Frequency rate	12.34	11.08	11.62	9.49	11.13
Severity rate	549	407	2315	452	930.75

injuries are recorded under similar procedure; here also some cases were rejected from inclusion in the statistics on the basis of the physician's report or in accordance with American Standard Association rules.

Injury Records

The construction and maintenance forces of the division operate from three sectional districts. They function as units within a prescribed area with certain services furnished by the other sections of the division on a city-wide basis. This discussion will be confined to the three operating districts which had 549 of 700 nondisabling in-

The distribution division has reduced its frequency rate from 12.34 in 1954 to 9.49 in 1957; the three operating districts, for the same period, have reduced their frequency rate from 17.06 to 14.37.

The higher hazards of distribution construction work are also confirmed by statistics which show that for the 4-year period the nondisabling accidents reported for construction work were 380, and for maintenance, 169. These figures are more significant when the 4-year data show that approximately 50 per cent of the field

work crews are assigned to each of the two work classifications.

This analysis demonstrates that the balance of this article can be concerned with the work activities of the construction forces. The agencies of injuries and accident classifications are comparable to maintenance work only in the determinations necessary for improvement in safe work procedures.

TABLE 6

Causes of Injuries

Agency	No. of Injuries
1. Automobile or truck	5
2. Casting, cast-iron cap and wood plug	3
3. Chips and slivers, metal, concrete, or wood	2
4. Containers	1
5. Equipment	4
6. Elevator	1
7. Excavation or trench, vault	16
8. Excavation spoil, dirt, debris, broken concrete, bricks, rocks, miscellaneous	8
9. Flammable liquids or vapors	3
10. Gas, utility, in trench	1
11. Heat, sun, humidity	1
12. Hydrant, fire	2
13. Lead, molten	1
14. Lids or rings of basins or vaults	2
15. Lumber, blocking	5
16. Machines	4
17. Materials, bag of cement	1
18. Pumps, gas engine for dewatering	3
19. Pipe, all types	10
20. Stairways, steps and ladder	3
21. Sign and standard	1
22. Streets, walks, and surfaces at work site	11
23. Tools, hand	7
24. Tools, power	9
25. Truck, hand, warehouse	1
26. Truck, personnel or material	2
27. Valve, 36-in. water	1
Total	108

Injuries Analyzed

Table 6 shows the causes of the 108 disabling injuries suffered by the division's construction workers in the period 1954–1957. To summarize 27 agencies of injury shown in Table 6:

1. Twenty-four disabling injuries resulted from trench excavations or spoil of various types from the excavation.

2. Nineteen injuries were incurred by employees working on the installation of pipe and appurtenances in trenches.

3. Sixteen injuries resulted from the use of hand and power tools.

4. Work-area activities involving employees' use of streets, walks, work surfaces, stairways, steps, and ladders, were the source of fourteen injuries.

5. The operation of machinery and miscellaneous equipment was the source of thirteen disabling injuries.

6. Miscellaneous materials accounted for nine injuries.

7. Five employees were injured by automobiles or trucks: three were struck at the work site, one was injured as the result of a truck out of control striking an office trailer, and

TABLE 7

Disabling Injuries Classified

Classification	No. of Injuries
1. Stuck against or by falling, flying or moving object, or automobile or truck	42
2. Falls	21
3. Caught in running or meshing objects, or between moving and stationary objects	6
4. Caught in trench cave-ins	10
5. Overexertion in lifting, pushing, or pulling objects	18
6. Burns from flammable liquids, vapors, gas, or molten lead	5
7. Bodily reaction (involuntary motion)	3
8. Exposure to sun, humidity	1
9. Foreign body in eye	1
10. Penetration by object being handled	1
Total	108

one was injured while hooking up a truck and trailer. Two additional injuries resulted as employees were working with the division's trucks.

8. Flammable liquids, vapors and utility gases were the source of four injuries. Humid heat and a falling sign and standard produced two disabling injuries.

Table 7 divides the agencies of disabling accidents into ten general clarifications; the 108 disabling injuries fell into the "nature of injury" classifications shown in Table 8.

TABLE 8

Nature of Disabling Injuries Classified

Classification	No. of Injuries
Amputations, distal joint	2
Burns	5
Contusions, with lacerations, sprains, and strains	38
Foreign object in eye	1
Fracture, wrist	2
Fracture, thumb	2
Fracture, pelvis, with contusion and shock	2
Fracture, toe	9
Fracture, leg	2
Fracture, ankle	3
Fracture, foot bone	2
Fracture, rib	1
Fracture, vertebrae disc	1
Heat prostration	1
Hernia, inguinal	8
Lacerations, head, face, leg, arm, hand	8
Sprains and strains, leg, ankle, knee	8
Strains, back, abdomen, hip	13
Total	108

Safety Equipment and Clothing

Many accidents and injuries can be mitigated, or prevented altogether, by the use of personal-safety equipment and proper clothing.

Hard Hats

To date, the distribution division has had only moderate success in the use of hard hats by employees on pipeline construction work. Many objections are voiced, such as: "too hot in the summer," "too cold in the winter," "the hat falls off when I bend over," "too big," "too small," "these are fibre (or plastic), we need metal hats," and so on.

Hard-hat elastic chin straps and liners for cold weather have been provided; perhaps brightly colored hats with a flashy decal emblem may be the next step to create a desire to wear a distinctive head gear.

In spite of the only-moderate success of the division in inducing employees to wear them, the hard hat appears to have been of value in the promotion of safety thinking and awareness. It is worn by most employees in trench work and tunneling, and in 1957 none of the districts reported a head injury which a hard hat would have prevented. Through field inspection, official reports, and periodic safety bulletins, hard-hat or safety-helmet use is constantly promoted. This safety item will probably always require such persuasion when the varied activities of water distribution construction work do not, in all cases, substantiate its need.

Safety Goggles

Eye injuries are easily guarded against; therefore, the loss or impairment of a worker's eyesight is not only a regrettable occurrence, but a direct indictment of the manager, the supervisor, and the employee.

The construction forces have had one disabling eye injury in 4 years, and superficial investigation at the time of the injury (1954) disclosed that some question as to disability existed. The number of nondisabling eye injuries for

the Chicago Bureau of Water for the 4-year period of its safety work has totaled 96. The largest classification of these, 52 in number, has resulted from airborne dust or ashes. In spite of this good record, it is still necessary to regulate supervisors and men closely to insure compliance with the safety rules covering this hazard.

The most numerous potential sources of construction employees' eye injuries are: cutting cast-iron pipe, pouring and calking lead joints, and breaking pavement with air-powered paving breakers. These hazards are reduced as the use of mechanical-joint pipe and concrete pipe, which have fewer lead joints to pour and calk, becomes more general. The division has also promoted the extensive use of mechanical pipe cutters and power pipe saws. In the cutting of cast-iron pipe, however, elimination of the danger of eye injuries will not be attained until supervision has available, and uses when possible, mechanical cutters or pipe saws for all cast-iron-pipe cutting operations, both in the trench and on the bank.

Safety goggles have been used in construction work for more than 35 years. They are supplied by the distribution division to its employees. There are unsolved problems in the use of safety goggles in pavement-breaking operations:

1. Complaints of clouding from perspiration cannot be taken too seriously, although at times it may be necessary to supply a liquid to prevent this. (The provision of prescription-lens safety glasses, as distinguished from goggles, for employees is not permissible for any Chicago municipal agency.)

2. Wearing safety goggles and eyeglasses, while handling a 90-lb paving breaker, is uncomfortable and annoying, but it is not unbearable.

3. Some employees, wearing eyeglasses, operate breakers without safety goggles and, as a result, the eye glass lens become pitted, scratched, or broken, and, even if an eye injury does not occur, the employee has to bear the cost of repairs.

4. Employees who are not regularly assigned to operations which require safety goggles usually leave their goggles in the construction trailer, and if they are assigned to use paving breakers they proceed without safety goggles. Supervisors must exercise close safety control over this work procedure even though safety rules direct the compressor operator to shut off the air supply if the employee user is not wearing his safety goggles.

5. Different types of welding goggles, and welding helmets with shaded lenses, must be provided for acetylene welding, cutting torches, and arc welding processes.

Safety-Toe Shoes

There were, for the period 1954–1957, seven fractured toe cases, all of which might have been prevented if the employees had been wearing safety-toe shoes or boots. Previous to the division's safety program, the use of safety-toe shoes and hard hats was a rarity. To date, considerable progress has been made in promoting the use of these items.

The more general use of safety-toe shoes and boots and requiring their use by all employees appears to be dependent on the establishment of some method of partial compensation to the employee for his purchase of safety-toe footwear. Metal toeguards are furnished by the division, and their use

is required by any employee using the air-powered paving breakers.

In 1957, disabling toe-fracture injuries were the least for the 4-year period; there were fourteen nondisabling foot and toe injuries from contusions, as compared to a high of eighteen in 1955.

Gas and Fume Masks

Disabilities or accident cases involving the inhalation of gases, fumes, or dusts have always been considered in the construction work of the distribution division. There have been no injuries of this nature reported by this division for the term of its safety program.

Chlorine masks and fresh air masks are used in the chlorination of water mains; dust and metal fume masks are used in a variety of work procedures. The special hazards encountered in the application of coal tar enamels to steel pipe joints, couplings, and welds are provided for, not only by the specific respirator, but also by special airtight safety goggles, and by protective creams and rubberized work gloves.

In addition, air movers and compressed-air lines are used to dispose of fumes from lead-joint burning or welding procedures, and the displacement of suspected contaminated or explosive-gas-content air from vaults, excavations, or tunnels.

In a recent, hazardous repair work operation, in a 145-ft deep water pipe tunnel, 1,200 ft in length, special detectors disclosed the presence of explosive gas after the tunnel had been dewatered. The safety section worked closely with the construction crew to control this and the other safety hazards, and the job was completed without incident, after these and several other safety procedures were instituted and carried out.

Clothing

Normally, each employee must supply his own work clothing. Only for special jobs, such as tunnel work, does the division supply waterproof jackets and trousers and, if required, waist-high waders.

Proper work clothing is a "safety must" in division construction work. It provides protection against contamination or infection of the skin, and against many types of scratches, lacerations, and abrasions. Clothing should be kept clean, and free from tatters, tears, and loose ends. Trousers and jacket cuffs should be buttoned or tied. Morale and safety awareness is indicated, to a surprising extent, by the employee's work clothing and general appearance.

Adequate work clothing and footwear for work operations in cold weather is not too costly for purchase by employees. Some construction crews have, at their own instance, adopted types of clothing which have allowed necessary construction work in extreme cold weather without too much personal discomfort. The author recalls only one reported case of frozen fingers in the division.

Cost of Safety Equipment

The safety section surveys each requisition for items pertaining to safety in any of the department plants or field operations. Its approval is required. Requests approved in 4 years, including such items as rubber aprons, signs, acid showers, hand trucks, and torches, have required the total expenditure of $137,000.

The extensive purchase of flasher lights for street work protection, trucks and mobile equipment, hard hats, special collapsible barricades, signs, safety cans, truck hoists, hydraulic tail gates and other safety items, many of them of a type not formerly in use, is attributed to the division's intensified safety activities.

Cave-ins

Trench cave-ins are possibly the cause of the most dangerous type of distribution-construction employee injury, and, therefore, they merit special mention.

Employee fatalities or permanent total disabilities frequently are caused by the completely unwarranted occurrence of trench cave-ins. The two most serious types of employee injury, a fractured pelvis with severe contusions and strains, and two fractured leg cases, plus six additional disabling injuries with various contusions, lacerations, and sprains, all were incurred by division construction employees in the last 4 years as a result of the caving in of trenches.

From the inception of the division's safety program the proper sheeting and bracing of pipe trenches and excavations for the repair of leaks, miscellaneous replacements, and minor construction has been constantly promoted by the safety section through safety manuals, data sheets, and field surveys. Administrators and district superintendents have consistently promoted this phase of safety in construction.

Sufficient quantities of sheeting lumber, timbers, and screw braces are stocked for all normal requirements. Special types of lumber and bracing can also be readily obtained, and for certain types of work, steel sheet piling with an air-powered driver is available.

It appears that some foremen take a chance, excavate with the machine, and try to set the pipe quickly and get the men out before the banks cave in. Other foremen are meticulous about sheeting and bracing, and in almost all cases their work is accomplished more quickly with less utility repair work, or pavement or curb repairs, and at a lower cost, and certainly with greater peace of mind and employee safety.

During 1957 no disabling accident injuries from caving trenches occurred, but, as yet, the full cooperation of all crew foremen in sheeting and bracing trenches in an approved safe manner has not been obtained. It is hoped that the continued attention of general foremen and section superintendents, together with the field surveys of the division safety engineer, will increase present partial compliance to a point where this serious safety hazard is under control. Unfortunately, the men who work in dangerous trenches are in many cases unconcerned about the danger of a cave-in.

Hernias

Hernias also merit special mention. The division construction force employees incurred eight chargeable inguinal hernias, none of them suffered as the result of an accident; all were due to overexertion in lifting or pushing and pulling objects.

Instructions in safe, approved manual lifting procedures, the use of the available mechanical lifting devices, and the assignment of experienced and physically competent laborers to the use of paving breakers should aid in the reduction of this class of accident

injuries. It should also be borne in mind that hernia cases ordinarily are in the suspect class of injury, unless a direct incident or accident can be connected with the other required factors.

Construction Crew Organization

The following resulted in accident injuries for construction employees:

1. Struck against, or struck by, falling, flying, or moving objects, 42 injuries
2. Falls, 21 injuries
3. Caught in running or meshing objects, or between moving and stationary objects, six injuries
4. Overexertion in lifting, pushing or pulling objects, and involuntary body reactions, 21 injuries
5. Others, such as burns and heat, six injuries.

There are certain definite requirements in crew organization which are necessary to provide for the smooth, efficient operation of a hand or machine pipelaying job, no matter what size water pipe, the type of pipe, or where the pipe is being installed—in good or poor ground, tunnels, bridge structures, or under water. If the work is properly organized and supervised, if the engineering design is such that it copes with the construction problems presented, and if the proper machinery, equipment, power and hand tools, personal safety items, barricading, lighting, and provisions for first-aid and medical care are available, then a pipeline construction job can be accomplished with a minimum of employee or public accident injuries.

A pipeline construction job is a piecework production line. The supervisor must organize his crew to meet the requirements of the operation. In this manner he can control the full work-day activities of men and machines. Falls, for example, are multiplied if employees hasten unduly, or if they meander deliberately about the job site on unnecessary errands to fetch items which should be at the work site. Materials and tools lying about the work site, as a result of poor housekeeping procedures, fall into trenches or result in falls of employees. The division's only total permanent disability case resulted when a heavy piece of blocking fell into a trench and struck a mechanic on the back, damaging his vertebrae and a disc. Employees may also be lifting, pulling, pushing, or hauling materials or equipment while suitable power equipment for the task stands idle.

From the supervisor's standpoint, the first step necessary is crew organization, the set-up to do the job using the available machinery and equipment. Good organization results in efficient production-line procedure, with the gratifying bonus of greater safety to employees, the public, machinery, equipment, and the existing distribution facilities. The exposition of policies, job duties, and procedures should bring out the necessity that each employee be aware of the need for doing his operation in a safe manner, and for him to be constantly on watch to preserve the safety of all other employees and work operations within his view.

A few organizational requirements for a well-conceived, efficient, and safe water-pipe installation crew are:

1. Excavation machinery, trenching, backhoes, and cranes, must be adequate for the trench required. The backhoes and cranes have the power and stability to set the pipe and fittings. The operator must be competent and experienced,

and impressed with the need for cables, brakes, drums, controls, conveyors, and other operational devices of the machinery to be in first-class condition within the manufacturer's prescribed limits. Machinery must be serviced and inspected before the start of the day's work, and during the lunch-hour shutdown. In the distribution division this work is performed by the assigned oiler and engineer. Each piece of key machinery such as trenching machines, backhoes, draglines or clamshell cranes must have a regularly assigned signalman. The standard signals in use must be generally known to all job employees concerned. The signalman for machines used in setting pipe or fittings functions as hookman and rigger.

2. Mobile machinery, such as lifts, bulldozers, truck cranes, and trucks, must not operate in work areas except at the direction of a signalman or a specifically assigned employee.

3. Employees working in trenches at the point of excavation must function in accordance with orders of the signalman who directs the excavation machine. When a trenching machine is in use it has been found advisable for the signalman to use a shrill whistle for signals to the machine operator; trench workers must obey these signals.

4. All tools, small materials, equipment, blocking, sheeting, and bracing should be delivered to the work site by truck and distributed. The employees assigned to this function have the important duties of aiding in installing trench bracing as the excavation proceeds, keeping the work area clear, serving the laborers in the trench, and assisting the hook man in setting the pipe and fittings.

5. Mechanics assigned to trench work, such as making pipe joints, setting castings and valves, reconnecting service pipe, and other tasks, must have a man on top of the trench assigned constantly to serve their needs, watch for their safety and assist in placing additional trench bracing or resetting braces. No employee should be left to work alone in the excavation at any point on the job; standard practices for safety and efficiency require a top man to service and watch the employee in the excavation.

6. Backfilling operations must be carried on as a well-planned procedure. As most of Chicago's pipelaying operations are in improved areas, sand is used for backfill, at least to the top of the pipe. Such procedures as filling under the pipe and tamping, removal of bracing as backfilling proceeds, protection of water and gas services, conduits, cables, and sewers must all be considered. Competent employees should be regularly assigned to this work and to trench puddling and jetting, which cannot be done haphazardly. The removal of surplus dirt, deliveries of fill sand, topping of the trench, and opening completed areas to traffic are all a part of this important work operation. The crew assigned to this operation also has the responsibility for the placing of all barricading, signs for traffic control, opening and protecting pedestrian walkways, and policing and inspecting completed areas of the pipeline installation.

7. Upon completion of the day's work, certain groups of employees have clean-up and close-up assignments. All trenches must be safely braced, machinery must be removed from hazardous areas and guarded against operation by unauthorized persons.

Pipe and materials must be removed from traffic areas and guarded against creating an "attractive nuisance." After the placing of flasher lights of the required types, red lanterns, flares, barricading, and signs, the work site can be assigned to the care of the night watchman.

It is the author's opinion that proper crew organization results in efficient and safe construction. The procedures outlined should be carried out smoothly. Inspection by the supervisor at the close of each day's work can be an acknowledgment of a safe, efficient, and well-organized pipeline construction operation.

Acknowledgment

The distribution division's safety section maintains an individual safety record for the approximately 75 supervisors who are in charge of all of its office, yard, maintenance, and construction employees. One of these supervisors, after 4 years on heavy construction work, had no disabling injuries in his crew; another, under the same conditions, reported only two disabling injuries. Several other supervisors had records almost as good. The safety director gives recognition to the supervisors with the best records, and also commends, in general, all of the division's supervisors. They have contributed a great deal to the division's safety program, and are constantly improving their procedures, as evidenced by the good results in 1957.

References

1. *Annual Accident Data Reports, 1954–1957.* Dept. of Water & Sewers, Chicago, Ill.
2. *Accident Facts.* Natl. Safety Council, Chicago, Ill., p. 36 (1957).

C503–58T

American Water Works Association

TENTATIVE

AWWA STANDARD

for

WET-BARREL FIRE HYDRANTS FOR ORDINARY WATER WORKS SERVICE

This "Standard for Wet-Barrel Fire Hydrants for Ordinary Water Works Service" is based upon the best known experience and is intended for use under normal conditions. It is not designed for use under all conditions and the advisability of use of the material herein described in any water treatment plant must be subjected to review by the chemist or engineer responsible for operations in the locality concerned.

Approved as "Tentative" Jan. 26, 1958

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Characteristics of National Standard Fire-Hose Coupling Screw Thread

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Uniform Color Scheme for Fire Hydrants

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C503–58T

Tentative AWWA Standard for

Wet-Barrel Fire Hydrants for Ordinary Water Works Service

Sec. 1—Type of Hydrant and Character of Service

1.1. This standard embraces the various types and classes of wet-barrel (California type) hydrants for general water works service. The items described are hydrants with independently controlled compression type (working against or with the pressure) valves for each outlet, in which all valve working parts are mounted on the hydrant above ground line. Wet-barrel hydrants are intended for use on fire service water mains *only in climates where freezing does not occur.*

1.2. Hydrants shall be designed for a working pressure of 150 psi. Hydrants designed for higher working pressures are not covered.

1.3. References to the setting of hydrants are not included in this standard. For installation standards, see Standard for Installation of Cast-Iron Water Mains—AWWA C600.

Sec. 2—Supplementary Details to Be Specified

When hydrants are to be purchased under this standard, the purchaser shall provide specific supplementary information concerning the following details:

2.1. *Inlet connection*—size and type (see Sec. 5.8).

2.2. *Delivery classification*—designated according to the number of hose and pumper nozzles; for example: "one-hose nozzle," "two-hose nozzle," "one-pumper nozzle," "one-hose and one-pumper nozzle," "three-hose nozzle," "two-hose and one-pumper nozzle," "two-pumper nozzle."

2.3. *Bury length* (wet-barrel hydrants consist of two parts, the upper portion being referred to as the hydrant and the lower portion as the bury)—specify to nearest ½ ft measured from the face of the hydrant flange to the center of the connecting pipe.

2.4. *Diameter (nominal inside) of hose nozzles and pumper nozzle, if any*—in inches.

2.5. *Hose and pumper nozzle threads*—if in conformity with ASA B26 for "National (American) Standard Fire-Hose Coupling Screw Threads," so specify. If not ASA standard thread, specify the following details or supply a sample:

Outside diameter of male thread finished
Diameter of root of male thread
Number of threads per inch
Pattern of thread
Cut off . . . in. at top of thread
Leave . . . in. in bottom of valley.

2.6. *Harnessing lugs*—if required (see Sec. 5.9).

2.7. *Nozzle cap gasket*—if required.

2.8. *Color of finish paint above ground line.*

2.9. *Threaded boss at top*—the top of a wet-barrel hydrant may have a

threaded boss of sufficient thickness to receive a supplementary hose outlet valve, if desired. It must be specified by the purchaser.

2.10. *Direction to open*—left (counterclockwise), unless specified otherwise.

2.11. *Size of operating and cap nuts.*

2.12. *Requirement of data to be furnished by manufacturer*—if desired by purchaser:

a. Catalog data (see Sec. 3.1).

b. Assembled weight of hydrant (see Sec. 3.2).

c. Certified drawings of all parts (see Sec. 3.3).

d. Affidavit of conformance with this standard (see Sec. 3.4).

2.13. *Nozzle cap chain*—if required (see Sec. 5.12).

2.14. *Tensile strength of hydrant body flange bolts*—see Sec. 5.13.

2.15. *Paint*—type (if other than as set forth in Sec. 4.11, 6.1, and 6.2) and color.

Sec. 3—Data to Be Furnished by Manufacturer

3.1. After purchase, the manufacturer shall, if requested, furnish catalog data (including illustrations and a schedule of parts and the materials of which they are made) in sufficient detail to serve as a guide in the assembly and taking down of the hydrant, as well as in ordering repair parts.

3.2. When required, the manufacturer shall furnish a statement giving the total net assembled weight of each size of hydrant ordered.

3.3. When required, the manufacturer shall submit (without charge) one set of certified drawings of all parts showing the principal dimensions, construction details, materials used, and the finish thereof, for approval by the purchaser. When approved, no work shall be done or hydrants furnished that are not in accordance with the approved drawings.

3.4. The manufacturer shall, when requested, furnish the purchaser an affidavit stating that the hydrant and all material used in its construction, if ordered to conform with this standard, does in fact, in all detail, conform with the requirements of this standard.

Sec. 4—Materials

4.1. *General.* All materials designated hereinafter shall, when used in hydrants produced under this standard, conform to the requirements designated below for each material listed. When reference is made to ASA, ASTM, or other standards, it is understood that the latest revision thereof shall apply.

4.2. *Physical and chemical properties of components.* The requirements of ASA, ASTM, or other standards to which reference is made elsewhere in this text shall govern the physical and chemical characteristics of the hydrant components.

4.3. *Standard test procedures for components.* Whenever hydrant components are to be made in conformance with ASA, ASTM, or other standards, all test requirements or testing procedures specified therein shall be met by the hydrant manufacturer. The records of such tests shall, if required by the purchaser, be made available to him.

4.4. *Cast iron.* All cast iron shall conform to ASTM Standard A126, Class B (Gray Iron Castings for Valves, Flanges, and Pipe Fittings).

4.5. *Wrought iron.* When wrought iron is used, it shall conform to ASTM A84 (Staybolt Wrought Iron).

4.6. *Steel.* Steel shall conform to ASTM A107 (Hot-Rolled Carbon-Steel Bars).

4.7. *Brass or bronze.* Hydrant components made from brass or bronze shall be one of six grades:

Grade I—conforming to ASTM B62

Grade II—conforming to ASTM B132 (Alloy A)

Grade III—conforming to ASTM B132 (Alloy B), B98 (Type D, hard), or B150 (Alloy 1)

Grade IV—Rolled bronze (naval brass) conforming to ASTM B21 (Alloy A, one-half hard)

Grade V—conforming to ASTM B147 (Grade 8a)

Grade VI—conforming to ASTM B124 (Grade 2)

Grade VII—conforming to ASTM B61.

4.8. *Bolts and nuts:*

4.8.1. Body bolts and nuts shall conform to ASTM A307 (Grade B). Body bolt studs shall conform to the physical and threading requirements of ASTM A307 (Grade B). Rustproofing of body studs and bolts is not required on wet-barrel hydrants.

4.8.2. Gland bolts, where required, may be made of either Grade II, III, or IV bronze, or may be cadmium plated or zinc coated (ASTM A123), or rustproofed by some other process (Parkerizing, Sherardizing, or the like) disclosed to and acceptable to the purchaser. Gland bolt nuts shall be made of Grade II, III, or IV bronze.

4.8.3. Stuffing box bolts and nuts, where required, shall conform to Sec. 4.8.1 above and shall be rustproofed in accordance with Sec. 4.8.2 above; *or,* if bronze is used, it shall be Grade II, III, IV, or V.

4.9. *Packing.* Stuffing box packing shall be made of asbestos conforming to Navy Department Specification 33–P–26 (Type A); or flax conforming to Federal Specification HH–P–106. An O ring seal may be used. Hemp packing shall not be used.

4.10. *Gaskets.* Gasket material shall be sheet asbestos, rubber composition, or paper free from corrosive ingredients, either alkaline or acid.

4.11. *Paint.* Paint used in coating the hydrant, as required by Sec. 6.1, shall conform to the requirements of Federal Specification TT–V–51 asphalt varnish or Army-Navy Specification JAN–P–450. Exterior coating above the ground line (Sec. 6.2) shall conform to Federal Specification TT–P–86 (Type IV) unless otherwise specified by the purchaser.

Sec. 5—Design

5.1. *Iron and bronze—where used:*

5.1.1. *Parts of cast iron.* The parts where cast iron may be used are the hydrant barrel, the bury, hydrant extensions or risers, the bonnet, the packing plate, the nozzle caps, and small miscellaneous parts where the use of cast iron conforms to good practice.

5.1.2. *Parts of bronze.* The parts where bronze is used are:

Parts	Refer to Sec.	Grade of Bronze
Glands		I, II, III, IV, VI, VII
Gland bolts	4.8.2	II, III, IV
Gland bolt nuts	4.8.2	II, III, IV
Gland bushings		I, VII
Nozzles	5.10	I, VII
Stems or threaded portion of stems	5.11.1	II, III, IV, V, VII
Stem nuts	5.11.1	I, II, III, VII
Stuffing boxes		I, VII
Stuffing box bolts and nuts	4.8.3	II, III, IV, V
Valve seats and valve seat rings and valve carrier	5.14	I, II, III, IV, VII

Reference should be made to the sections of this document where the above components are detailed. In several instances, ferrous metal, properly treated, may be used instead of bronze.

5.2. *Valve openings.* All hose outlet valve openings shall have a waterway equal to or larger than the nominal size of the outlet.

5.3. *Valve facing.* The individual valves of the hydrant shall be faced with a suitable yielding material—such as rubber, leather, balata, or composition—where it bears on metal seats. The material shall be clamped so that the valve will not leak at the stem. The bottom stem threads may be protected by a suitable cap nut.

5.4. *Hydrant barrel wall thickness.* The thickness of the wall of the barrel shall be not less than is indicated below. The wall thickness of barrels of fractional-inch diameter shall be that for the next larger diameter listed. The specified thicknesses are:

Barrel ID *in.*	Min. Wall Thickness *in.*
5	0.47
6	0.50
7	0.54
8	0.58
9	0.65
10	0.73

5.5. *Barrel sections.* If hydrants are made in two or more sections with a flange or other joint near the ground line, the joint shall, unless otherwise specified by the purchaser, be located at least 2 in. above the finished grade line.

5.6. *Waterway.* Changes in the shape or size of the waterway shall be accomplished by means of easy curves. The junctions of nozzles with the barrel shall be rounded to ample radii. The net area of the waterway of the barrel at the smallest part shall be not less than 120 per cent of the sum of the net openings of the pumper or hose valves.

5.7. *Friction losses.* With the bury piece or bury piece and extension 5 ft in length, measured from the bottom of the connecting pipe to the ground line, and discharging 250 gpm through each 2½-in. hose outlet, the friction loss shall not exceed the following:

Flow *gpm*	Pressure Loss *psi*	No. of 2½-in. Outlets
250	1	1
500	2	2
750	3	3
1,000	4	4

5.8. *Hydrant inlet.* The base of the hydrant shall have a side or bottom inlet, provided with a bell, a flange, or other type of connection as specified or approved by the purchaser for connecting the hydrant to the branch from the main. The inlet shall be suitable for connection to pipe of not less than 6-in. nominal diameter, *unless otherwise ordered.*

When a hydrant is provided with bell-type connections, the bell dimensions shall conform to those shown in AWWA C100 (Class D). When a hydrant is provided with flange-type connections, the flange dimensions shall conform to ASA B16.1 (Cast Iron Pipe Flanges and Flanged Fittings, Class 125). When a hydrant is to be connected to mechanical-joint pipe, the bell dimensions shall conform to Table 11.1 of ASA A21.11 (AWWA C111).

If deemed necessary by the manufacturer or the purchaser, the bell flange may have the top one or two holes slotted to the edge of the metal.

5.9. *Lugs.* Lugs, if required, for harnessing the hydrant to the connecting pipe from the street main shall be provided on the bell of the elbow.

5.10. *Joining nozzles to barrel.* Nozzles shall be of Grade I or VII bronze and shall be fastened into the barrel by a fine thread or secured by a properly gasketed locknut or by leading. If lead is used, an adequate recess shall be provided for the lead. All nozzles shall be safeguarded against blowing out. For screwed-in nozzles, a pin or other approved method shall be employed to prevent the nozzle from turning or backing out.

5.11. *Valves:*

5.11.1. The operating stems of valves shall be made of Grade II, III, IV, V, or VII bronze and the stem nuts of Grade I, II, III, or VII bronze.

5.11.2. The design factor of safety of the operating mechanism shall be five, and shall be based on foot-pounds torque required for the closing and opening of individual hydrant valves at 150-psi working water pressure. Hydrants shall be capable of being opened or closed after being subjected to an opening torque of 200 ft lb applied at the operating nut. The diameter of operating stems shall be not less than $1\frac{3}{16}$ in. at the base of the threads and for the remainder of the stem.

5.11.3. Operating stems and stem nuts shall have square, V, or Acme threads.

5.11.4. Operating stems shall be assembled with other valve parts so that they cannot become disassembled during hydrant use.

5.11.5. Valves shall be so designed that when operated under severe conditions, no part will break before failure of the stem or stem nut.

5.12. *Nozzle caps.* Nozzle caps shall be of cast iron and shall be provided for all outlets. The threads shall conform to those of the nozzle. Unless otherwise ordered, caps shall be securely chained to the hydrant barrel or valve, with a metal chain having links made from stock not less than $\frac{1}{8}$ in. in diameter, or of equivalent cross-sectional area. A recess shall be provided at the inner end of the threads to retain a gasket.

5.13. *Removal of hydrant body.* The hydrant body complete with operating valves shall be so designed that it may be removed by unbolting from the bury section above the ground line. The bury section and the top section shall be cast with facing flanges, and, if so specified by the purchaser, the bolts provided shall have a tensile strength less than the shear force required to break the hydrant body.

5.14. *Valve seats and valve carriers.* Valve seats or seat rings and valve carriers shall be made of Grade I, II, III, IV, or VII bronze.

5.15. *Valve operating and cap nuts.* The valve operating nuts and nuts on the nozzle caps shall be of pentagonal shape with dimensions conforming to the standards of the system where the hydrant is to be installed.

Sec. 6—Painting and Marking

6.1. *Coating.* All iron parts of the hydrant, inside and outside, shall be thoroughly cleaned and thereafter, unless otherwise stipulated, all surfaces inside and outside (except the exterior portion above the ground line) shall be coated with asphalt varnish (Sec. 4.11). They shall be covered with two coats, the first being allowed to dry thoroughly before the second is applied.

6.2. *Shop coating above ground line.* The outside of the hydrant above the finished ground line shall be thoroughly cleaned and thereafter painted in the shop with two coats of paint of a durable and weatherproof composition (Sec. 4.11) which shall produce a surface

to which later coats of paint having a linseed oil or other approved base will readily adhere. The color or colors to be used shall be as specified by the purchaser.

6.3. *Marking:*

6.3.1. All hydrants shall have permanent markings identifying the manufacturer by name, initials, insignia or abbreviations in common usage, and the year in which the hydrant was manufactured. Marking shall be so placed as to be readily discernible and legible after hydrants have been installed.

6.3.2. The AWWA mark on a product indicates that it has been made in strict conformity with AWWA standards. No manufacturer shall place on a hydrant the initials "AWWA" in any form other than the mark, and then only when he has applied for and been granted a license to do so in accordance with AWWA certification procedure.

Sec. 7—Workmanship

7.1. All foundry and machine work shall be done in accordance with standard good practice for the class of work involved; in conformance with approved drawings, if required; and as approved by the inspector representing the purchaser. When assembled, hydrants manufactured in accordance with this standard shall be well fitted, smooth operating, and watertight.

7.2. All parts shall conform to the required dimensions and shall be free from defects which will prevent proper functioning of the hydrant.

7.3. All machined parts shall be made to template or gage.

7.4. All joints shall be faced true and shall be watertight when subjected to the water pressure for which the hydrant is designed.

7.5. All iron parts receiving bronze mounting shall be made true and smooth, and the bronze mounting shall be finished to fit.

7.6. All castings shall be clean and sound, without defects which will impair their service. Repairing of minor defects will be permitted only where these defects do not affect the strength or impair the service of the hydrant.

7.7. All like parts of hydrants of the same model and size produced by the same manufacturer shall be interchangeable.

Sec. 8—Hydrostatic Test

8.1. Hydrants for a working pressure of 150 psi or less shall be subjected, after assembly, to a shop test under a hydraulic pressure of 300 psi. The test shall be made with the whole interior of the hydrant under pressure. Under the above test procedure, there shall be no leakage through any of the valves, nor through the castings or the joints of the assembled hydrant. Leakage or other imperfections found in either test shall be corrected before the hydrant is delivered to the purchaser.

8.2. Hydrant valves shall be fully opened and closed to insure full operation.

Sec. 9—Inspection

9.1. All work under this standard shall be subject to inspection and approval by the purchaser's duly authorized engineer or inspector, who shall at all times have access to all places of manufacture where materials are being produced or fabricated or where tests are being conducted, and who shall be accorded full facilities for inspection and observation of tests. Any

hydrant or part which he may condemn as not conforming to the requirements of this standard shall be made satisfactory or shall be rejected and replaced.

9.2. If the purchaser has no inspector at the plant, the manufacturer shall, if so requested at the time the order is placed, certify by sworn affidavit that the required tests on the various materials and on the completed hydrant have been made, and that the results of all tests conform to the requirements of this standard (see Sec. 3.4).

Sec. 10—Preparation for Shipment

Hydrants shall be complete in all details when shipped. The manufacturer shall use due and customary care in preparing them for shipment, so that no damage due to the manufacturer's negligence will occur in handling or in transit. Hydrants must be drained and completely closed before shipment.

APPENDIX A

Characteristics of National Standard Fire-Hose Coupling Screw Thread

Basic dimensions of National (American) Standard hose coupling screw threads are shown in the following tabulation. The complete document (ASA B26) may be obtained at a price of $1.00 per copy from the American Society of Mechanical Engineers, 29 West 39th St., New York.

Characteristic*	Nominal ID of Hose Coupling—*in.*				
	2½	3	3½	4†	4½
Number of threads per inch	7½	6	6	4	4
Total length of threaded part of hydrant nipple, external (minimum)—*in.*	1	1⅛	1⅛	1¼	1¼
Distance from face of nipple to start of second turn—*in.*	¼	5/16	5/16	7/16	7/16
Depth of coupling swivel to washer seat—*in.*	13/16	1 1/16	1 1/16	1 1/16	1 1/16
Distance from face of coupling swivel to start of second turn—*in.*	3/16	¼	¼	⅜	⅜
Depth of thread of coupling swivel—*in.*	11/16	11/16	11/16	11/16	11/16

* Outer ends of external and internal thread should be terminated by the "Higbee Cut" on *full thread* to avoid crossing and mutilation of thread.

† Dimensions in this column approved by National Fire Protection Assn., 1956 (not ASA standard).

APPENDIX B

Uniform Color Scheme for Fire Hydrants

The American Water Works Association, recognizing that the adoption of a capacity marking scheme by any water department is optional, herewith provides the following uniform color scheme for painting hydrants rated in terms of their relative capacity.

1. Hydrants are classified as follows:

Class A: Hydrants that on individual test usually have a flow capacity of 1,000 gpm or greater.

Class B: Hydrants that on individual test usually have a flow capacity of 500 to 1,000 gpm.

Class C: Hydrants that on individual test usually have a flow capacity of less than 500 gpm.

Capacities are to be rated by flow measurements of individual hydrants at a period of ordinary demand. When initial pressures are over 40 psi at the hydrant under test, the rating is to be based upon 20-psi residual pressure, observed at the nearest hydrant, connected to the same main, from which no water is being drawn. When initial pressures are less than 40 psi, residual pressures shall be at least half of the initial.

2. The following is the capacity-indicating color scheme:

2.1. *Public hydrants.* All barrels are to be painted chrome yellow except in cases where another color is desired. The tops and nozzle caps of the classes as outlined in Sec. 1 are to be painted as follows:

Class A—green
Class B—orange
Class C—red

2.2. *Private hydrants.* Within private enclosures, the marking is to be at the discretion of the owners. When in public streets, they should be painted to distinguish them from public hydrants.

3. All location markers for flush hydrants should carry the same color background as stated above for class indication, with such data stenciled or painted thereon as may be deemed necessary.

4. The colors shall signify only the approximate capacity of the individual hydrant as tested alone and not its capacity when more than one hydrant in the vicinity is in use. The marking of the hydrant is not to be considered as in any way guaranteeing the capacity indicated by the color.

NOTE: This color scheme was adopted by the American Water Works Association at its 1937 Convention at Buffalo and was originally published in the April 1937 JOURNAL, p. 449.

The color scheme duplicates, in essentials, similar plans adopted by the Maine Water Utilities Assn. in 1929, by the New England Water Works Assn. on Mar. 21, 1934, and by the National Fire Protection Assn. on May 14, 1936.

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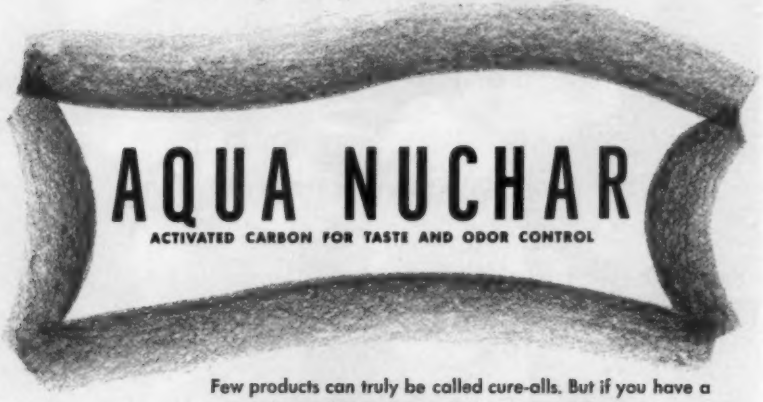

Few products can truly be called cure-alls. But if you have a taste-odor problem at your plant, whatever the cause, we sincerely believe AQUA NUCHAR is the cure!

It's a proven fact. Properly applied in adequate dosage, AQUA NUCHAR activated carbon effectively adsorbs all taste- and odor-forming substances recorded to date in water supplies.

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Our research staff is available without obligation to discuss your taste and odor problems with you. We will gladly recommend economical, dependable controls using AQUA NUCHAR. Call, wire or write today.

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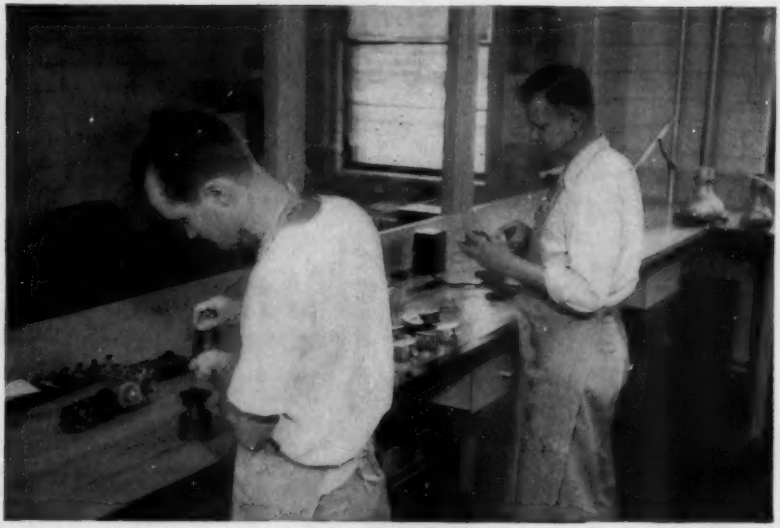

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If you have Trident water meters, your department is probably the only service in your community equipped with *Automatic Modernization* . . . a process which costs far less than "scrap and replace" programs.

Every time you replace work-worn parts in a Trident disc meter, you automatically use modern parts identical to those in the *latest* model . . . parts embodying every thoroughly tested advancement known to the science of metering.

No need to keep complicated stocks of parts for many models . . . just keep a small stock of modern parts. It's easier to train service men, too. Your men need learn only one simple, fool-proof model, and they can service all.

Designing modern Trident parts so they'll fit "old" meters has been a rigid Neptune policy for 60 years. *Every design improvement now on our drawing boards will continue this policy.*

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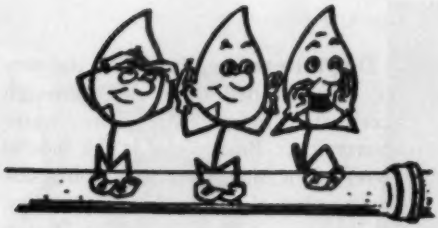

Percolation and Runoff

Brussels sprouted AWWAers during the last week in May when the International Water Supply Congress brought in a steady stream of water works men to compact the fill of Fair visitors already on hand and underfoot in the Belgian capital. There to participate in the sixth conference of the international group were, at least, Fred Merryfield, "Sig" Sigworth, Harry Faber, John Knutson, Rafael Urrutia (fresh from hosting his own international meeting in Puerto Rico), and Harry Jordan. The official report of what was accomplished is not yet available, nor, as a matter of fact, is most of the unofficial scoop, for a good many of the delegates are still on tour. Strong confirmation of the less than enthusiasm with which Americans, at least, are viewing the US exhibit at the Fair has, however, already been indicated. Yet, from a sanitary engineering viewpoint, we understand, the exhibit is anything but a flop—offering the only free restrooms on the grounds. All of which makes us wonder if the reported observation that "the US exhibit hits new bottoms every day" was really intended as a criticism.

Hitting a new top, meanwhile, was the US showing in the water supply meeting as American participation in the activities of the international association continues to grow. And this participation appears to have even the highest "official" approval, for when "Sig" embarked to undertake the task of general reporter on taste and odor control in water supplies, he carried with him telegraphic congratulations and best wishes from Undersecretary of State Christian Herter and US Senator J. Glenn Beall. And, of course, John Knutson and Harry Faber were delegates direct from officialdom. Next thing we know, AWWA will signify All World Water Association.

All Western World Association, anyway, for it may take just a little longer to develop an iron removal method effective on curtains. On the other hand, the indications are most encouraging. Just the other day the headlines carried the news that Khrushchev, himself, had gone on the water wagon—at least temporarily—to demonstrate his support for President Nasser of the United Arab Republic. Although he didn't go all the way—stopping at mineral water—who knows but that Nik's gesture of respect for Moslem abstention from alcohol may not one day, soon, lead to the invention

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(*Continued from page 43 P&R*)

of public water supply. As a matter of fact, almost simultaneously, Moscow's chief statistician officially announced that 86 per cent of that city's houses now have running water, and a full 39 per cent even have bathtubs. With water there, can the swing (to AWWA) be far behind?

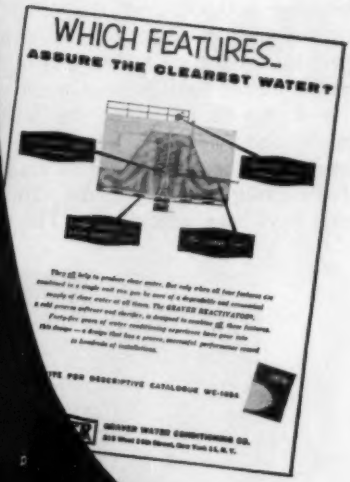
Preliminary plans for the Fifth Nuclear Congress to be held in the Public Auditorium, Cleveland, Ohio, Apr. 5–10, 1959, have been announced by Engineers Joint Council. As in the past the congress will be composed of four parts: the Nuclear Engineering & Science Conference, the Hot Laboratories & Equipment Conference, the Atomic Energy Management Conference, and the Atomfair, at which nuclear equipment will be on display. Clarke Williams of Brookhaven National Lab., chairman of the Nuclear Engineering & Science Conference, announced that papers will be considered for inclusion in the 1959 program if summaries are submitted before Oct. 1, 1958. Prospective authors should submit 300–500 word summaries to the secretary of any one of the sponsoring societies (AWWA is one of the more than 25 sponsors). Papers selected will be those presenting the most recent and outstanding developments in the nuclear field. Topics in the past have included reactor design, power plants, radiation techniques, instrumentation, shielding, waste disposal, and related items.

For general information on the congress, write to T. A. Marshall Jr., Congress Mgr. (or L. K. Wheelock, Asst. Congress Mgr.), c/o Engineers Joint Council, 29 W. 39th St., New York 18, N.Y.

Down to the sea in sips is the way we seem headed these days through accelerated research in saline water conversion. Basically it is the federal government that has been doing the accelerating through the Department of Interior's Office of Saline Water. And now, with Senate approval on Jun. 10 of Joint Resolution SJ 135, it appears that the program will soon be augmented by the expenditure of an additional $10,000,000 to build five demonstration plants—three (two of at least 1-mgd capacity) to handle sea water and the other two (of not less than 0.25-mgd capacity) to treat brackish water. The basic idea, of course, is to learn if, under plant-scale operation, means can be found to bring the cost of desalinization down to the present goal of between 25 and 50 cents per 1,000 gal. One group that claims to have reached this goal already is building a 3.6-mgd plant in South Africa's Orange Free State gold fields to desalt a 3,000-ppm water to the 500-ppm level using the electrodialysis process with paper membranes. Cost, including power, interest on investment, 15-year amortization, pretreatment, and bulk distribution, is predicted at 29 cents per 1,000 gal. The conditions, of course, are quite different and the 29 cents is still subject to the adjustment of fact, but it shouldn't be too long before we can all enjoy a Scotch and Atlantic.

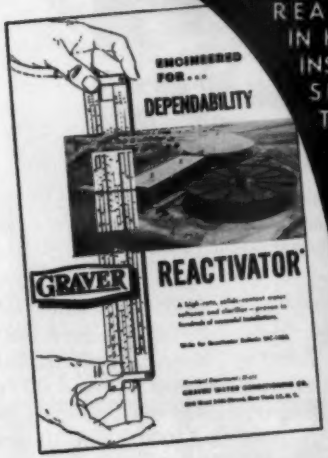
Even now, of course, sea-sipping is being done. As a matter of fact, in the past 5 years, some twenty desalting plants of various sizes and types have been reported. Two of these in the Persian Gulf area are handling "one of the saltiest waters in the world (42,000 ppm)"—one at Bahrein Island

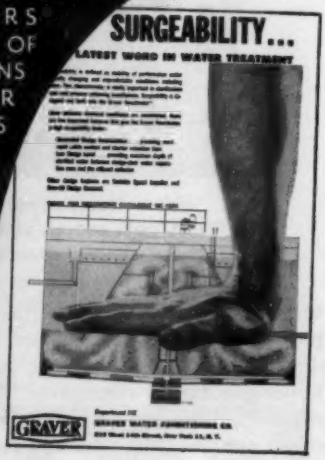
(*Continued on page 46 P&R*)



No Matter How We Say It

THE RESULTS BEING PRODUCED BY GRAVER REACTIVATORS IN HUNDREDS OF INSTALLATIONS SPEAK FOR THEMSELVES





GRAVER WATER CONDITIONING CO.
Division of Union Tank Car Company

M-420

216 West 14th Street, New York 11, N.Y.

(Continued from page 44 P&R)

producing 100,000 gpd, the other at Kuwait, producing 2.5 mgd now and scheduled for 5 mgd by the end of the year. Smaller units nearer home are to be found in Bermuda, the Virgin Islands, and Aruba. And, within the past few months, plans for two municipal desalting plants in the United States have been announced. The first of these is to be at Key West, serving a population of 53,000 civilians and Navy personnel, to replace the supply now being obtained through a 129-mi pipeline from the mainland. By using low-cost exhaust steam from a municipal power plant and a distillation process, it is expected that a 2-mgd plant could be built and operated to produce a water at "comfortably less than Key West's present domestic rate of $1 per 1,000 gal." The second plant, also involving a special situation, is to be installed late this year in Coalinga, Calif., to serve a population of 6,000 whose drinking water has been supplied by rail to supplement the brackish well water available locally. Although reduction of dissolved solids from 2,000 to 290 ppm by electrodialysis is expected to cost $1 per 1,000 gal for plant operation only, the city will save more than $400,000 in 10 years at that rate.

Sal-ud!

Fresh water supply preserved in salt. Something to look, as well as to get, into these August days—even at $1 per 1,000 gal.

(Continued on page 48 P&R)

EASY TO INSTALL CUTTING-IN VALVES FOR BETTER CONTROL

MECHANICAL JOINT

M & H Cutting-In Valves and Cutting-In Sleeves have mechanical joints designed to work with various classes of cast iron pipe. By cutting a short section of correct length out of an existing pipe line, the Sleeve and Valve are easily installed by unskilled workmen. The Cutting-In Valve is the same design, construction and materials as M & H A.W.W.A., double disc gate valves, except for the mechanical joint and connections designed to work with various outside diameters of different classes of pipe. These valves are available with O-Ring seal or conventional stuffing box. Sizes, 4" through 12". Write or phone for details.

M&H VALVE AND FITTINGS COMPANY
ANNISTON, ALABAMA

SUBSIDIARY OF WALWORTH

(*Continued from page 46 P&R*)

Don't discard your atlas if you can't find Lake St. Lawrence in it, because up until 8:59:50 AM of Jul. 1, 1958, there was no such lake. That was the moment when Great Lakes water, held in check by a cofferdam blown up an hour earlier, reached the foot of the St. Lawrence River power dam at Massena, N.Y., on the Ontario border. Lake St. Lawrence, with its drop of 81 ft, will provide the water power for a $600,000,000 hydroelectric project serving New York, Vermont, and eastern Canada.

Speaking of lakes, contracts have been signed by the Southeastern Michigan Water Authority and the consulting firm of Black & Veatch for the latter to draw up specifications for a 96-in. pipeline to transport Lake Huron water to southeastern Michigan. The project, scheduled for operation in 1961, will cost an estimated $131,000,000. Detroit and other communities may take part.

Fluorinews is making an even bigger spread these days with the help of no less accomplished disseminators than Drew Pearson and *Look* magazine. It was Pearson who took on the Daughters of the American Revolution and the chairman of their National Defense Committee for their opposition to fluoridation. And though, unfortunately for him, his facts slipped a bit in reporting that New York City "adopted fluoridation," his column undoubtedly reached an audience previously untouched by a good many of his "pro" arguments. Then *Look,* in its issue of Jun. 24, must have provoked some additional thought with a strongly favorable article, which not only told the story of a referendum victory in New Canaan, Conn., but went out of its way to pick out and answer the opposition's arguments.

Meanwhile, the opposition had its day at Manhasset, N.Y., when residents of the Manhasset-Lakeville Water Dist. rejected fluoridation 1,856 to 468. And the *National [Anti-]Fluoridation News* not only seized upon Pearson's error, but "demonstrated" by the panel discussion in last October's JOURNAL (p. 1239) that the concentration of fluorides cannot be maintained in the distribution system.

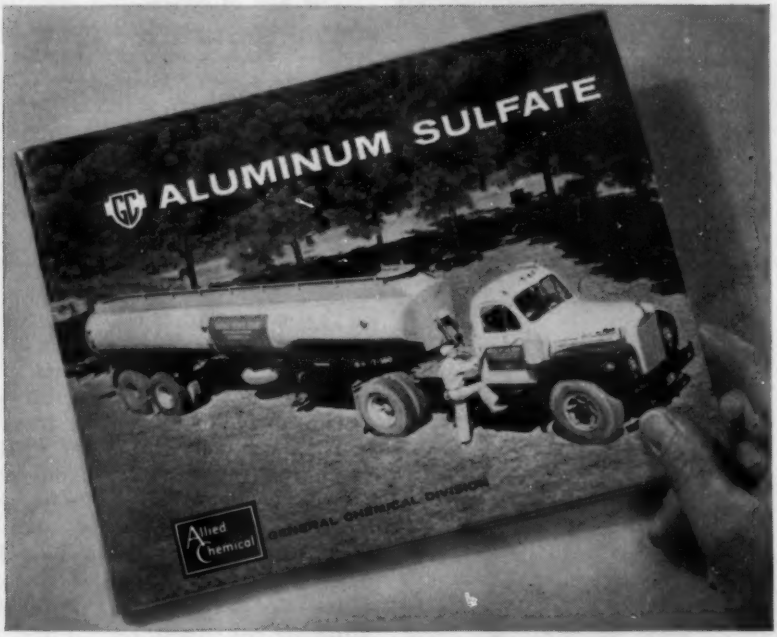
Less controversially, it was reported that, at Norwood Village, Wash., a residential community near Seattle and one of the few places in the area with fluoridated water, the exchange rate established for residents of nearby towns was said to have been set at 5 gal of fluoridated water for a fifth of vodka.

And so it grows!

A culture medium for engineers has been established at the University of Michigan, Ann Arbor, where students can now take a 5-year program leading simultaneously to the degree of Bachelor of Science in Engineering (Civil Engineering) and the degree of Bachelor of Arts. The university believes that the cultural background of a civil engineer can greatly influence his effectiveness on the job by determining how well he can work with persons unfamiliar with engineering but expert in social and economic matters. Consequently, the program includes courses in languages, literature, fine arts, philosophy, and history, as well as general science and engineering. A student must complete four semesters in the Literary College and six plus a summer session in the Engineering College.

(*Continued on page 50 P&R*)

NOW! from General Chemical...



Helpful New 32-Page Data Book on ALUM

Every user of aluminum sulfate should have this important new technical bulletin! Prepared by General Chemical, America's foremost Alum producer, this fact-filled book contains carefully selected data which Alum consumers need most often and find most helpful.

Having special emphasis on liquid Alum, it provides authoritative information on:

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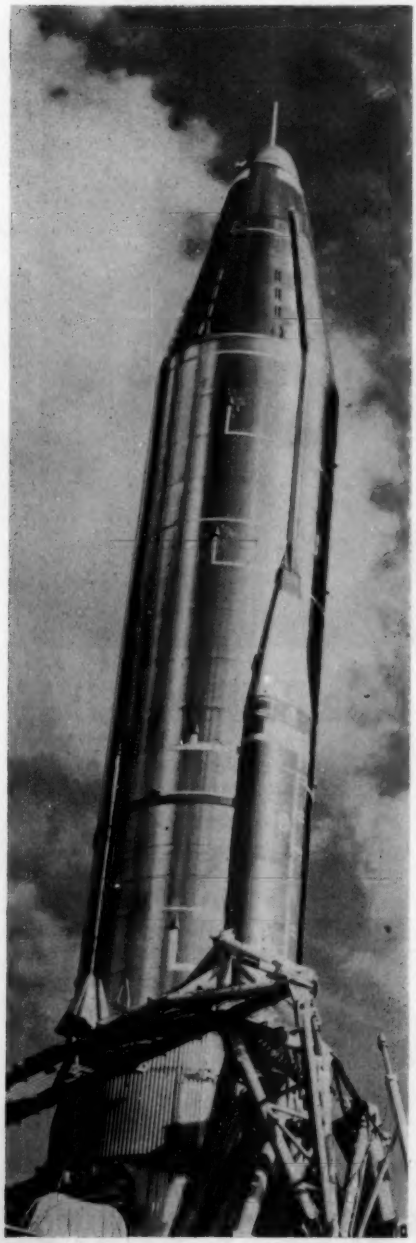
(Continued from page 48 P&R)



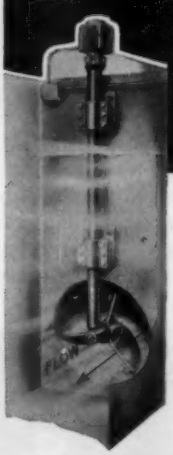
The age of space—like everything else—seems to start and finish with water. Thus, poised for countdown (see cut), the Air Force Atlas ICBM won't blast off until it has its water—a thorough wash with completely de-ionized water to remove any residue that might cause local "hot spot" corrosion while the missile is speeding through the atmosphere. But the problem of de-ionization is routine. Hungerford & Terry, Inc., of Clayton, N.J., using Rohm & Haas Co. resins, in a short time equipped the Air Force missile center at Cape Canaveral, Fla., with six ion-exchange units that will provide more baths than there are Atli.

The real problem gets under the skin of the missile, where there is no room for storage of enough water for prolonged human flight and—even if there were—no means of handling that much weight. Thus, chemists and engineers are working hard on plans for providing not only drink, but food, by recycling liquids and solids to make the missile virtually a self-contained unit in space. As a matter of fact, descriptions of how weightlessness makes it necessary to squeeze food, in the form of paste, and drink into one's mouth from plastic tubes, pictures in *Time* magazine like that of Bill Ingram double-distilling urine to recover pure water, the idea of taking along algae to transform our wastes back into food, and the discovery that the loneliness of such a trip will make us both depressed and irritable has just about made us change our mind about going. Somehow—perhaps because the temperature is above 90—a swim in the ocean and then a thick, juicy steak and some beer have more appeal right now.

Meanwhile, perhaps they ought to take a look around for some of the light water that must have been left

(Continued on page 52 P&R)

When measuring through the discharge end of a submerged throat or conduit, DEPEND ON . . .



10″ to 72″

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WATER WORKS INTAKE METERS

Sparling Water Works Intake Meters are designed to provide efficient and economical service. Ideal for a large volume of water flowing through the discharge end of a submerged throat or conduit. The very simplicity and variety of models available permit wide application . . . often using the existing headwalls or supports. Propellers may be plastic or stainless depending upon installation and use. Maintenance is simple. Available with Sparling's new Indicator-Totalizer 245. Drop pipes can be any length. Ideal for use in telemetering systems. 10″ to 72″

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El Monte, Calif.

(Continued from page 50 P&R)

when all that heavy water was consumed in the atomic energy program.

Annual awards for the best operated water and sewage plants in 1957 have been announced by the Florida Board of Health. Treatment categories (various population classes) and recipients are: lime softening—Richard L. Priester (operator, St. Augustine) and Leon C. Jackson (operator, St. Petersburg's Cosme water plant); coagulation and filtration—J. L. Burnett (supervisor of filtration, Tampa); primary plant—Edward T. Helms (superintendent, Winter Haven).

Scotch and water hit the headlines last month in a rather unusual combination—the Scotch was straight, but the water was at the business end of a hose, where it served to capture a burglar red-nosed. Wilfred, the red-nosed burglar, was an ex-bootlegger who decided to try a new racket. He bought some burglar tools and one evening late in May broke into the first-floor office of a Park Avenue dentist in New York. Finding a bottle of Scotch, he settled down in the dentist's chair and forgot all about gold teeth and platinum fillings until the bottle was empty. As it was morning by then, he started to leave through

David B. Lee (left), director, Bureau of Sanitary Engineering, Florida Board of Health, with award winners Priester, Burnett, Jackson, and Helms. See story above.

(Continued on page 54 P&R)

IS SEA WATER DISTILLATION PRACTICAL?

At Maxim we can say sea water distillation *is* practical for shore-located communities, because we are proving it daily at our Marine Testing Station, the first facility of its kind and still the only one using continuous full density sea water. At this station sea water distillation units are continually under test to improve economy as well as mechanical performance.

Your inquiry on the practicality of sea water distillation for your community is invited. The cost of sea water conversion with Maxim equipment is already at a point where communities with difficult fresh water supply problems will find such installations economically feasible.

THE MAXIM SILENCER COMPANY

Subsidiary of Emhart Manufacturing Company

110 Homestead Avenue, Hartford, Connecticut

(Continued from page 52 P&R)

the window but bumped into someone in getting out. With rare presence of mind, he explained that he was the window washer—but, unfortunately, he was talking to the window washer, who turned his hose on him and called the police. Now Wilfred, the redness of his nose quite faded, is back in jail with plenty of time to figure out some less hazardous career. And in our dentist's chair, looking at the repaired venetian blind, we casually ask Dr. Clayman if he has replaced the Scotch. After all, it was WATER that captured the thief!

Speaking of water as a weapon, though, we recall the excitement in Miami last month, when customs agents were called out to investigate a shipment of 15,000 pistols that was on its way to Cuba. The information was correct, of course, but they were water pistols—Castro convertibles, perhaps!

Vulcan Materials Co. has opened new headquarters for its Concrete Pipe Div. at 721 Angier Ave., N.E., Atlanta, Ga. Burton D. Smith, formerly sales manager of the division's Southern Cen-Vi-Ro Pipe Corp. at Mobile, Ala., has transferred to the new Atlanta offices to become sales manager —pressure pipe for the Concrete Pipe Div.

Robert K. Levey, customer service director of Mueller Co., Decatur, Ill., has retired after nearly 30 years with the firm.

Noel S. Chamberlin has been appointed manager of the newly formed Chemical Process Dept. of Graver Water Conditioning Co., New York. The new department will be responsible for the application of unit process operations to the purification, processing, separation, or recovery of products in various industries. Mr. Chamberlin was with Wallace & Tiernan Inc. for many years and more recently has been associated with the consulting firm of Havens & Emerson, New York.

Employment Information

Classified ads will be accepted only for "Positions Available" or "Position Wanted." Rate: $1.50 per line (minimum $5.00), payable before publication. Deadline for ad copy: first of month prior to month of publication desired. To place ad, obtain "Classified Ad Authorization Form" from: Classified Ad Dept., Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

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Position available for a well educated, aggressive young Engineer with several years' experience as an Engineer and Chemist in the field of water supply. Unusual opportunity for advancement and professional recognition on Long Island with an expanding organization comprised of a large group of properties. Salary commensurate with experience and ability. Interview arranged on basis of letter stating qualifications, educational background and salary desired. Reply Box 881A, Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

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General Manager, Chief Engineer, Superintendent, Registered. Lifetime progressive experience. Interested connecting with utility organization, consulting engineer, manufacturer or contractor. Box 882W, Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

MORE WATER FOR MIDLAND

Armco Pipe feeds new 100-million-gallon reservoir at Midland, Michigan

Midland, Michigan, is joining hundreds of other cities using Armco Welded Steel Pipe to meet increasing demands for water supplies. Shown here is the 36-inch-diameter Armco Pipe being installed for the inlet of Midland's new 100-million-gallon reservoir.

This reservoir is part of Midland's continually expanding water supply program. Over the past eight years, nearly 30,000 feet of Armco Pipe in various diameters from 8⅝ inches to 36 inches have been used to help meet the city's need for more water.

Armco Pipe can help solve *your* water supply problems too. Write us for information related to your particular requirements. Armco Drainage & Metal Products, Inc., 3188 Curtis Street, Middletown, Ohio. Welded Pipe Sales Division. Subsidiary of Armco Steel Corporation. In Canada: write Guelph, Ontario.

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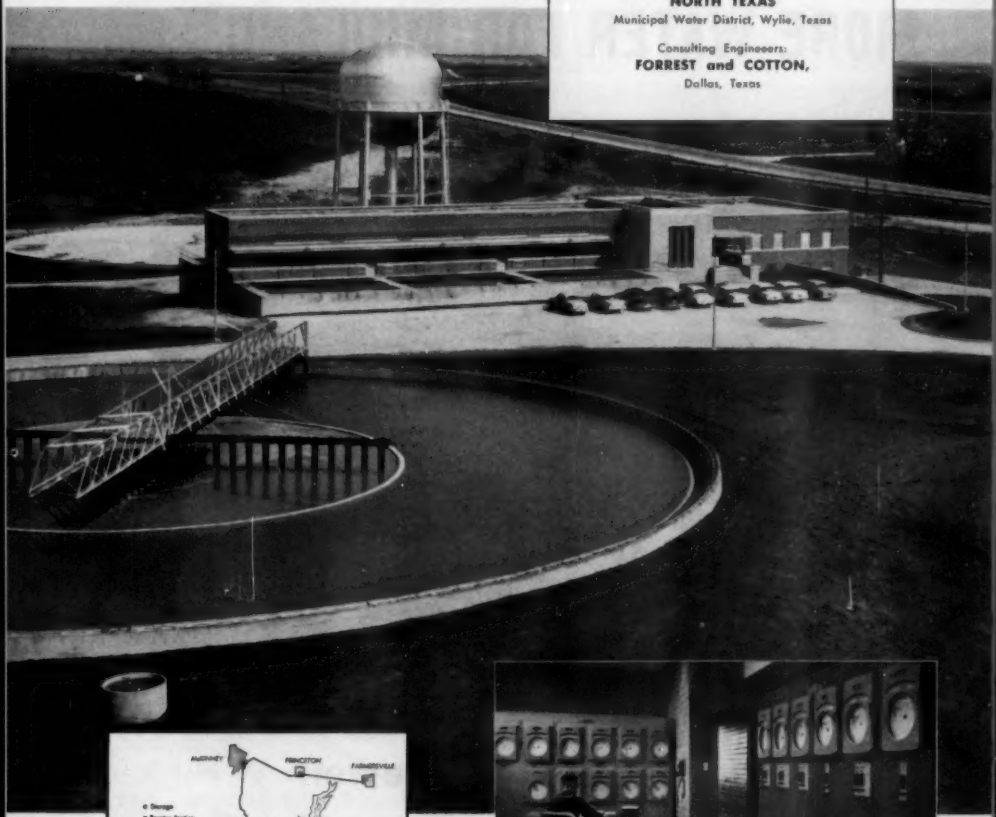

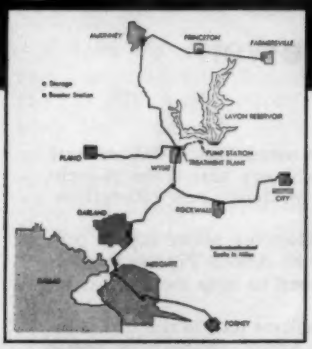

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Selecting equipment and controls for an operation spreading over four separate counties is a major undertaking. A decisive factor in the choice of Builders-Providence was the ability and experience of this *one company* in supplying all equipment needed for telemetering and supervisory control, filter control, chemical feeding, and related functions.

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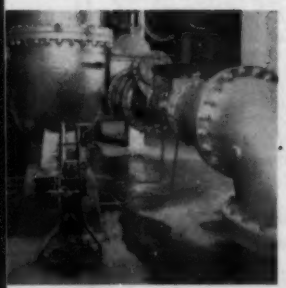
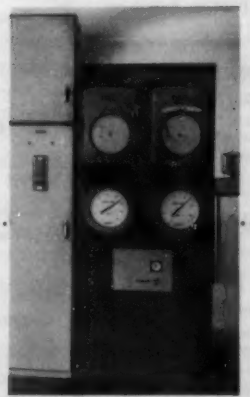


BUILDERS-PROVIDENCE PNEUMATIC MASTER CONTROL SYSTEM and rate-of-flow controllers provide dependable and instantaneous regulation of flows throughout entire system.



CONTROL PANEL in Dallas Pump Station continuously transmits local flows and levels to Wylie . . . from where Synchro-Scan master panel controls Dallas pumps to suit demands . . . further reducing operating costs.

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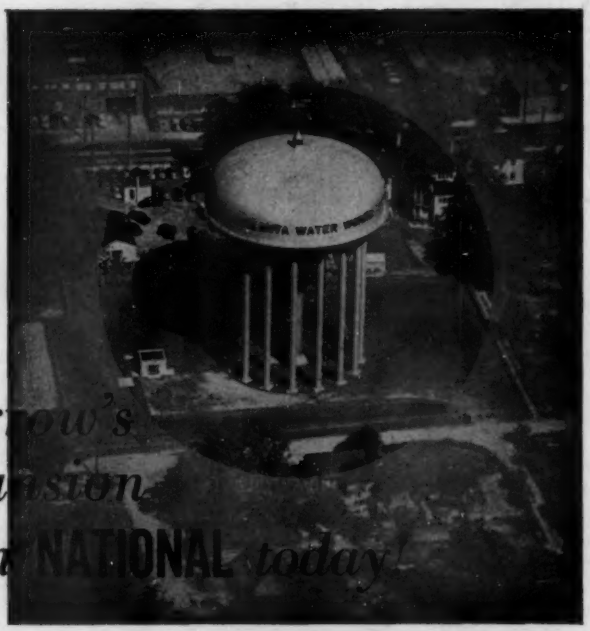

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Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

DISTRIBUTION SYSTEMS

Present Status of Plastic Pipe for Waterworks Use. B. HENDERSON. Munic. Utilities, 94:12:15 ('56). Description is given of uses and types of polyethylene pipes in water works and water-distr. systems in Can.—*WPA*

Effect of Air Conditioning on Distribution and Pumping Stations. C. K. MATTHEWS. Proc. ASCE, 82:SA1. Paper No. 889 ('56). Author outlines effects of water-cooled air-conditioning systems on design of water treatment plants and distr. systems. Methods are described by which effects can be estd. by comparison of hourly demands 10 yr. ago with present demands, of ratios of max. hr to avg. day, and of cost of improvements with and without nonconserved air conditioning. Methods, when applied to data from water distr. of Kansas City, Mo., indicate that air-conditioning installations can create demands on water distr. system which will require excessive extensions and expenditure if once-through air-conditioning systems are not prohibited.—*WPA*

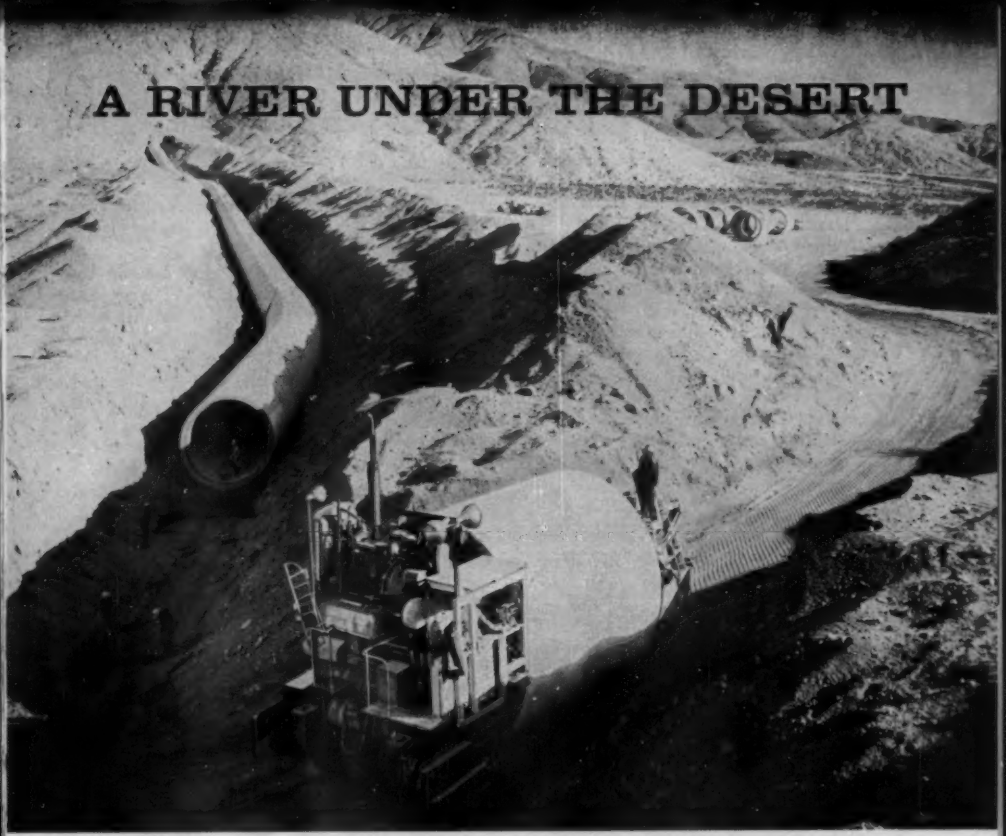
An Investigation of the Incidence of Underground Leakage and an Improved Method of Waste Control. E. G. B. GLEDHILL. J. Inst. Water Engrs., 11:117 ('57). Paper describes investigation of rate at which underground leaks break out and various expts. made to obtain information on other factors which affect what is generally known as "waste." Based on assumption that underground leakage from service pipes and mains breaks out at rate which is reasonably uniform, method is given involving use of leakage factors, whereby no. of leaks outstanding in any area at given time can be estd. Distinction between real and apparent min. flows is discussed and diversity factors suggested. Min. flows are analyzed on basis of exptl. data. Balanced method of sounding—termed "differential sounding"—is proposed which takes acct. of actual rate of leakage in various dists. comprising area of supply, and effect of pressures and subsoils. Examples of method are given, and comparison made with waste meter method of control; conditions for min. waste are considered and financial aspects discussed.—*PHEA*

Pressure Losses and Penetration of Polluted Water Into Water Distribution Systems. H. WITTMANN & W. BLEINES. Gas u. Wasserfach (Ger.), 98:556 ('57). Authors describe, with diagrams, causes of loss of pressure in pipes with constant and with variable flow and discuss calcn. of effect of incrustations on flow and pressure. Great reduction in pressure caused by incrustations can, with irregularities in operation, cause pressure in pipe to fall below that outside. With old pipes, where incrustations and thinness of pipe walls may coincide, poln. may be drawn into system.—*WPA*

Sanitary Hazards Associated With Vacuum Formation in the Water-Supply Network. A. G. MALIENKO-PODVYSOTSKII. Gigiena, 9:66 ('56). Negative pressure in water supply pipes is dangerous from sanitary point of view because contamd. ground water can be sucked into them through cracks and defects. Vacuum formation in water supply network occurs as result of differences in relief of territory through which pipes are laid, and inadequate power of installations. Author points out necessity of providing sensitive armature on water supply network which could prevent negative pressure in pipes by introducing air equal by vol. to water withdrawn from pipes.—*PHEA*

(*Continued on page 68 P&R*)

A RIVER UNDER THE DESERT



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(*Continued from page 66 P&R*)

Water Pipe of Prestressed Concrete. J. VAN DIJK. Water, **39**:191 ('55). With development of water supplies of The Hague, Amsterdam and province of North Holland it was necessary to have bigger and higher-pressure pipe. Prestressed concrete pipe solved problem. Pipes with diams. of 1.2, 1.4, and 1.5 m were constructed with lengths of 5 and 6 m. These had working pressure of 6–7 atm. Drawings are given for several types along with pictures of constr., transportation, and laying of pipe. Pipes are made by centrifugal process.—*PHEA*

HYDRAULICS

Model Tests on Hydraulic Problems of Settling Tanks With Baffles. M. SZALAY. Hidrol. Kozlony (Hung.), **36**:142 ('56). Model tests were carried out at Budapest Tech. Univ. on hydraulics of baffled sedimentation tanks. In expts. on sedimentation of sand it was found that, while without baffles sand was deposited along whole length of tank, area of sand deposition could be reduced to ⅓ of tank length when baffles were added. Advantages of sedimentation tanks with baffles over unbaffled tanks include smaller space requirements, low costs of constr., and greater eff.—*WPA*

A Graphical Solution for Flow in Earth Channels. I. D. CARINO. Proc. ASCE, **83**:IR2, Paper No. 1360 ('57). Author presents graphical soln., using Manning's formula, for design of earth canals with trapezoidal cross-sections. Graphs were prepared for specific value of coefficient of channel roughness closely approximating that for earth canals.—*WPA*

Turbulence in Civil Engineering: Turbulence in a Diffuser Boundary Layer. J. M. ROBERTSON & G. L. CALEHUFF. Proc. ASCE, **83**:HY5, Paper No. 1393 ('57). Measurements of turbulence intensity at 5 stations and of shear at 1 station in boundary layer on inside of a 7½ deg. conical diffuser are reported. Comparison of results with those for nonpressure gradient boundary layers indicates significant divergence from universal inner region concept. Microscale of turbulence appears to be fairly constant, although other turbulence quants. are greatly increased as flow develops in adverse pressure gradient.—*WPA*

The Measurement of Water Levels by Electrostatic Apparatus. Eau (Paris), **43**: 133 ('56). Electrostatic equip. for measurement of water levels in reservoirs and filters or of levels in chem. storage tanks, is described. App. needs no mechanical transmission of signals; it may be used without contact with liq. to be measured; and it is independent of conductivity of liq.—*WPA*

Surface Tension of Water in Natural Stagnant and Flowing Waters. P. LASSLEBEN. Naturwissenschaften (Berlin), **44**: 556 ('57). Author describes formation and appearance of "light water" on surface of natural waters. Such light water has, like ice, a looser arrangement of hydrogen and oxygen atoms. Effect of different rates of flow, temp., turbulence, and other factors on surface accumulation of light water is discussed.—*WPA*

Turbulence in Civil Engineering: Investigations in Liquid Shear Flow by Electromagnetic Induction. L. M. GROSSMAN; H. LI; & H. A. EINSTEIN. Proc. ASCE, **83**:HY5, Paper No. 1394 ('57). Authors describe method for measuring component veloc. fluctuation in turbulent liq. flows, based on induction of elec. potential field in continuous medium moving relative to stationary uniform magnetic field. Theoretical basis of method is analyzed, and description is given of its exptl. application to measurement of component veloc. fluctuations in fully developed turbulent flow of water in circular pipe.—*WPA*

A Study of the Flow of Liquid When Freely Trickling Over the Packing in a Cylindrical Tower. Z. CIHLA & O. SCHMIDT. Coll. Trav. Chim. Tchecoslov (Czech.), **22**: 896 ('57). Differential eq. has been derived for flow of liq. over layer of packing such as is used in gas-washing columns. Particular solns. are presented for various boundary and initial conditions.—*WPA*

Turbulence in Civil Engineering: Measurements in Free Surface Streams. A. T. IPPEN & F. RAICHLEN. Proc. ASCE, **83**: HY5, Paper No. 1392 ('57). Various tur-

(*Continued on page 72 P&R*)

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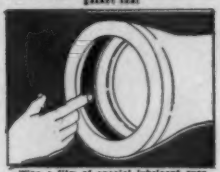
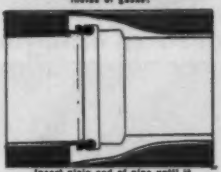
ONLY FOUR SIMPLE ACTIONS

Insert gasket with groove over bead in gasket seat



Wipe a film of special lubricant over inside of gasket



Insert plain end of pipe until it contacts gasket

Force plain end to bottom of socket . . . the job's done!

12" Tyton Joint pipe for water line in Florida

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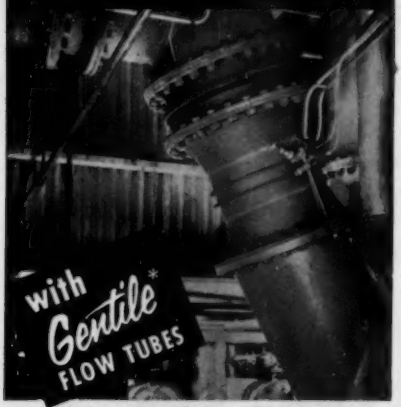
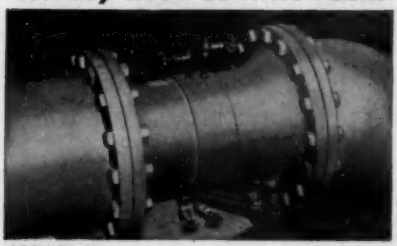


...they need so little room



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(*Continued from page 68 P&R*)

bulence phenomena in free-surface streams were investigated, using combination of total-head tube with capacitance-type pressure transducer. Design criteria for instrument are given, together with some performance data.—*WPA*

HYDROLOGY, CONSERVATION & IRRIGATION

Water Conservation on the Prairies. E. L. GRAY. Munic. Utilities, **92**:12 ('55). Water conservation is of vital importance on Canadian prairies where avg. annual pptn. is less than 20 in. Dependence on local annual pptn. results from lack of flowing streams; prairie streams last only few days and, therefore, storage is necessary. Hence crop rotation with fallow yr. is essential in these areas. After 1930, water conservation became national problem and legislation followed to provide funds for future water conservation program. In many instances, excavated or municipal ponds serve as water supplies for towns; towns of Nobleford, Alta., and Eston, Sask., are typical of towns using dugouts as water reservoirs and details of their ponds are given. Use of excavated reservoirs has been very successful in western Can. Numerous dams of various types have been constructed and helped considerably in this water conservation campaign. Included in conservation measures are use of increasing no. of reservoirs created by restoration or improvement of existing basins. As result of increasing use of irrigation, several large reservoirs have been constructed in southern Alta. and southwestern Sask. In addn. to using all available surface water in prairies, some ground water reservoirs have been utilized. Unfortunately, much of ground water has too high salt concn. for general use and, therefore, treatment is necessary. Details of pilot plant for demineralization of water by means of ion-exchange membranes, now being tested at Miller, S.D. (pop. 2,000) are given. Demineralizing units, in conjunction with extension of elec. services to rural areas, will open very extensive field in western Can. Poln. is not major problem in western Can.; use of lagoons for sewage disposal is spreading rapidly in western urban centers.—*WPA*

(*Continued on page 74 P&R*)

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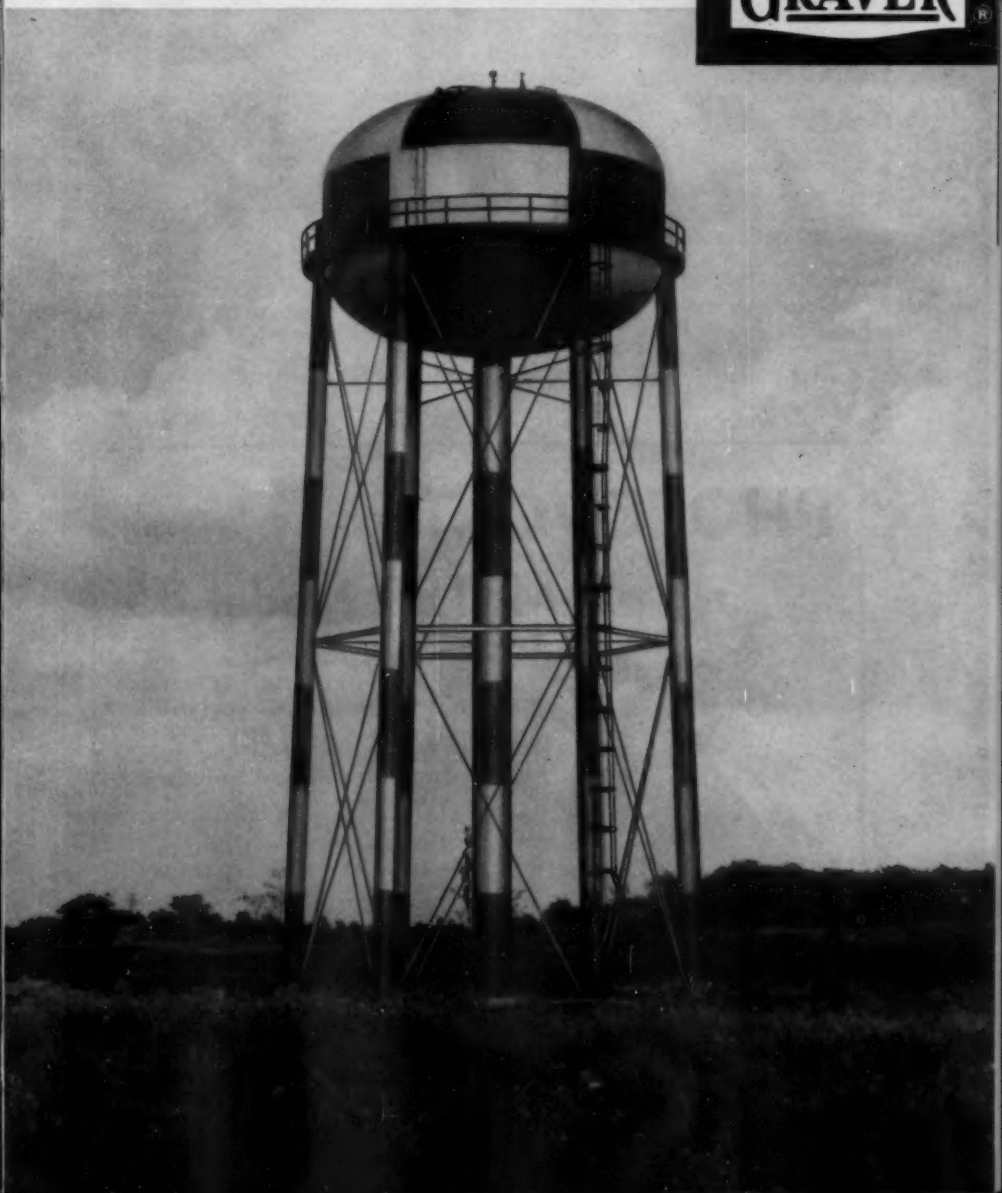

(*Continued from page 72 P&R*)

Reflections on Procedure for the Study of Aquifers. R. COLAS. Eau (Paris), **43**:127 ('56). Author gives formulae and graphs used in US for calcn. of coefs. of permeability, transmissibility, and storage of aquifers. Several methods for calcg. yield of wells are described briefly, and 1 method which does not involve pumping is described in detail.—*WPA*

The Degree of Regularity of Water Resources From Rainfall. L. PONCELET. Bul. Centre Belge Etude Document. Eaux (Liege), **30**:239 ('55). Monthly rainfall data for Meuse basin, Belgium, are analyzed and losses due to evapotranspiration are calcd., using Turc's formula. Author discusses effect of rainfall on flow of river and considers that no advantage would be gained by use of cloud seeding to increase rainfall in dry seasons. Article is illustrated by graphs and tables.—*WPA*

Recent Studies on the Problems of Underground Hydrology. F. DIXEY. Tech. Eau (Brussels), **10**:120:21 ('56). In study on ground water, author discusses yield of wells, veloc. and direction of flow of ground water, and pressure variation in artesian wells.—*WPA*

Economic Methods of Controlling Evaporation of Water. K. L. SUTHERLAND. Research (London), **10**:198 ('57). Economic method for reducing losses of water due to evapn. from large storage reservoirs in Australia has been devised. Successful lab. expts. using hexadecanol under controlled conditions are described and eqs. are presented for calcn. of results, some of which are given in graphs. Field expts. were also carried out using raft to maintain film of hexadecanol on surface of water. Details of these expts. are given, including illustration of raft used. Economic value of procedure when used to prevent losses of water during drought periods in Australia is em-

(*Continued on page 76 P&R*)

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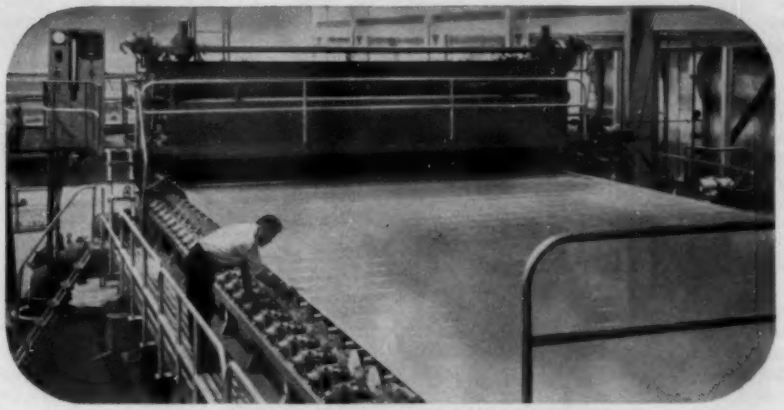

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(*Continued from page 74 P&R*)

phasized, but it is stressed that method may not be suitable for other countries. Further expts. using hexadecanol dissolved in petroleum are now in progress.—*WPA*

Hydrological Techniques Applied to Ground Water Problems in Grand Valley, California. R. L. BOKE & D. S. STONER. Tech. Eau (Brussels), 11:121:37 ('57). Irrigation network in Grand Valley, Calif., is supplied exclusively from ground water sources and Central Valley project is responsible for maintenance of this supply. Research has been carried out to est. storage capac. of these underground water basins and vol. of water available for their natural recharge and to det. qual. of ground water. Possibility of artificial recharge is also considered. Storage capac. of these underground "reservoirs" is estimated by calcg. permeability and specific yield of aquifers. Natural recharge of ground water depends on rainfall, and stations to measure rainfall throughout valley were set up; posts were also set up to measure uptake of water by evapn. and vegetation. Assuming that remainder percolates through soil to recharge ground water, value for vol. of recharge water can be calcd.—*WPA*

The Hydrochemical Characteristics of the Basic Genetic Categories of Surface Waters. P. P. VORONKOV. Doklady Akad. Nauk S.S.S.R. (Moscow), 111:438 ('56). Water samples, on basis of their anals. for HCO_3^- (the analyses for Na^+, Ca^{++}, SO_4^{--}, and pH play secondary role only) can be classified as surface-slope, soil-surface, soil-ground, and ground waters.—*CA*

100 Frequency Curves of North American Rivers. E. KUIPER. Proc. ASCE, 83:HY5, Paper No. 1395 ('57). Frequency curves of max. annual flood flows on important rivers in Can. and US are given. Frequency curves are drawn as straight lines, and it was found that inclination of lines is affected by drainage area, climate, and soil conditions.—*WPA*

(*Continued on page 78 P&R*)

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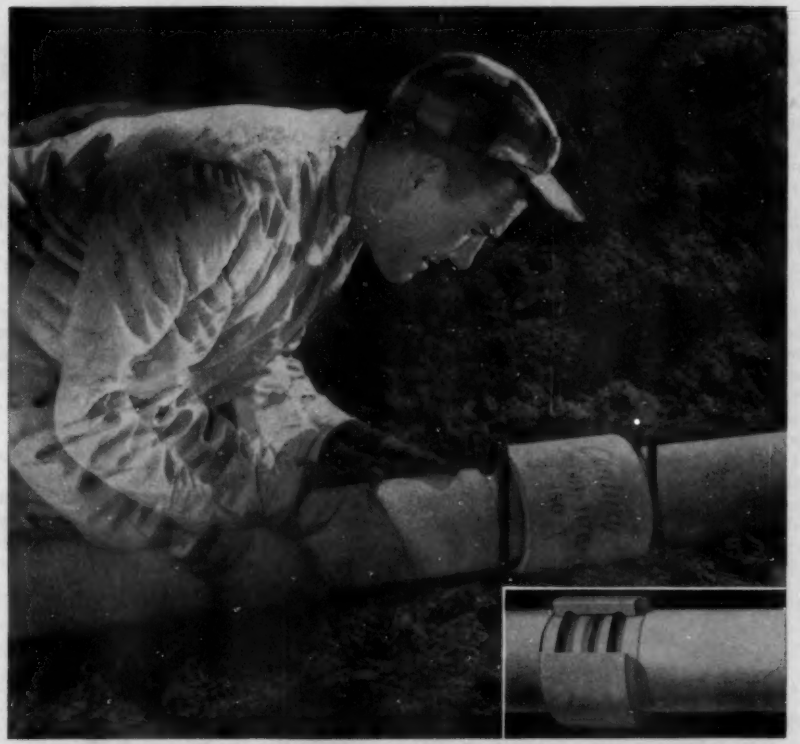

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(Continued from page 76 P&R)

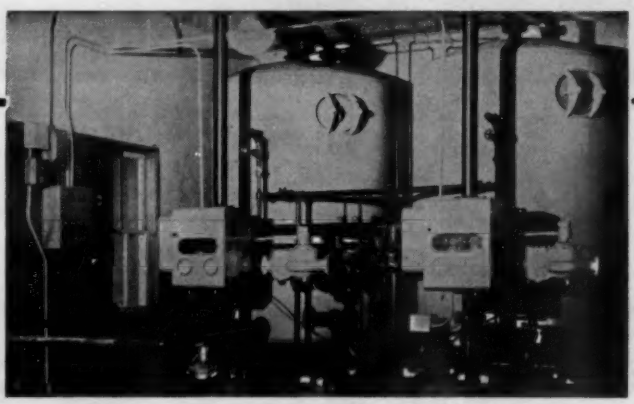
Some Glances at the Irrigation Technique of the United States. AUBERT & GUYON. Eau (Paris), **43**:135 ('56). Description is given of methods of irrig. used in states of Utah, Wash., and Ore., Columbia basin project and costs of irrig. Advantages of irrig. by sprinklers are discussed.—*WPA*

Methods of Determining Consumptive Use of Water in Irrigation. R. D. GOODRICH. Proc. ASCE, **82**:IR1, Paper No. 884 ('56). Author reviews literature on investigations into use of water by crops, and describes standard methods used to detn. consumptive use of water by crops, which is measurement not only of water used for vegetative growth but also of evapn. from surrounding soil and is, therefore, synonymous with evapotranspiration. Correlation of consumptive use of water data with certain climatological factors and assumptions made to apply results of study of 1 area to other areas are discussed, with reference to studies made in upper Colorado R. basin. List of references is appended.—*WPA*

State of Substances in Natural Waters. IV. Colored Substances. T. OKURA & H. SUZUKI. Nippon Kagaku Zasshi (Tokyo), **78**:617 ('57). For colored waters from peat regions, $KMnO_4$ consumption was proportional to ignition loss and color. Waters showed linear absorbance curves between 400 and 600 mμ. Waters deionized by mixed bed had pH values of 3.6–4.1 and specific resistance of 25,000–85,000 ohm/cm (20°). Color of natural waters increased with pH; at pH 2, coagulation of colored substances occurred. Negative charge of color substances in deionized waters of pH 3–9 was indicated by measurement of electrophoresis. However, charge in natural water varied with sample.—*CA*

Occurrence of Naphthenic Acids in Natural Waters of Various Compositions. E. P. MULIKOVSKAYA. Vsesoyuz. Nauch.-Issledovatel. Geol. Inst., Vaprosy Neftepoiskovoi Gidrogeol. (USSR), **18**:126 ('56). Alkali and alk. earth naphthenates occur in natural

(Continued on page 80 P&R)



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(*Continued from page 78 P&R*)

waters that have been in contact with petroleum. Waters high in general alky. are high in naphthenic acids (I); those in which Na^+ predominates contain more I than do those in which Ca^{++} predominates. High total mineral content lowers content of I. In water contg. more than 100 g/l NaCl, total alky. will no longer affect content of I. I are highest (up to several g/l) in H_2O high in Na^+ and HCO_3^-; H_2O high in Ca^{++} + HCO_3^- cannot contain more than 200–300 mg/l I.—*CA*

Acidity of Waters in a Tropical Forest Environment. G. ROUGERIE. Compt. Rend. (Paris), **246**:447 ('58). Tropical forest waters are not highly acid. Nitrification of atm. waters has been overestd., and local concn. in org. acids does not exceed that of swamp waters in temperate zone. Detns. on forest waters of Ivory Coast—runoff, marsh water, well water, creeks, and rivers—associated with various rock types, yielded values of pH between 5.2 and 7.2, min. value on water from quartz sands and max. from basic rocks.—*CA*

Water Resources Policy. R. W. MORSE. Am. J. of Public Health, **47**:452 ('57). Paper reviews our current water needs and mentions predictions of future water needs. Current research efforts are reviewed in field of evapn. control and saline water conversion. Recommendations of Presidential Advisory Com. on Water Resources Policy are outlined along with program that has been proposed to implement recommendations.—*PHEA*

The Effect of Withdrawal of River Water for Agricultural Irrigation on Low Water Flow. H. HORST. Deut. Gewasserkundl. Mitt. (Ger.), 1:6 ('57). Discussing influence of agricultural use of river and ground water, author deals with amts. required, duration of demand for addnl. water, effect of heavy rainfall during dry seasons, demands of different crops, necessity for storage, and use of sewage.—*WPA*

(*Continued on page 82 P&R*)

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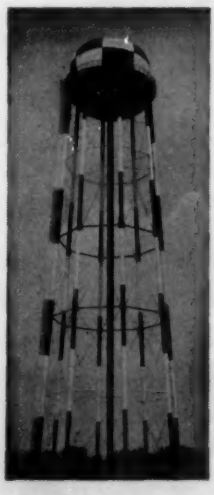

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(*Continued from page 80 P&R*)

INDUSTRIAL WATER USE

Water for Industry: The Rules Change. Eng. News-Record, **158**:9:28 ('57). In '54, survey was carried out in Cleveland, Ohio, area in effort to provide adequate water supply for both industrial and domestic purposes. It has been calcd. that by '75, present industrial water consumption will be doubled and only possible source of water for large quants. required is L. Erie. Supply projects proposed in report are concerned with bringing lake water to inland areas; these projects consist of inland supply systems which will divide interior into 3 entirely independent service areas, namely valleys of 3 major rivers—Black, Cuyahoga, and Grand. System is based on avg. daily demand; raw water will be delivered to different areas, treated by local authorities, then distributed. Costs of project are given.—*WPA*

Industrial and Public Water Supply. E. BAROCKA. Gesundh. Ing. (Ger.), **78**:148 ('57). Author discusses problems of industrial water supply, dealing with difficulties, advantages, and disadvantages of individual supplies and use of public supplies.—*WPA*

Water Treatment in the Textile Finishing Industry. O. REICHLING. Melliand Textilber. (Ger.), **36**:79 ('55). Compn. of water and methods of treatment for making water suitable for use in textile industry are described.—*WPA*

Water Supplies for Industry. R. COLAS. Centre Belge Etude Document. Eaux, Bull. Mens. (Belg.), **57**:215 ('55). Water consumption per unit of production, per worker per day, and per hectare of factory space, of large no. of different industries in Fr. is shown in table, and figures are discussed. Tables showing water consumption per worker per day and per year in various Belg. and Ger. industries are given for comparison, and some general statistics of water consumption in US, Ger., Belg., Sp., and Fr. are also included. Qual. of water required by some of major industries in Fr. is considered. Bibliographies are included in text. —*WPA*

(*Continued on page 84 P&R*)

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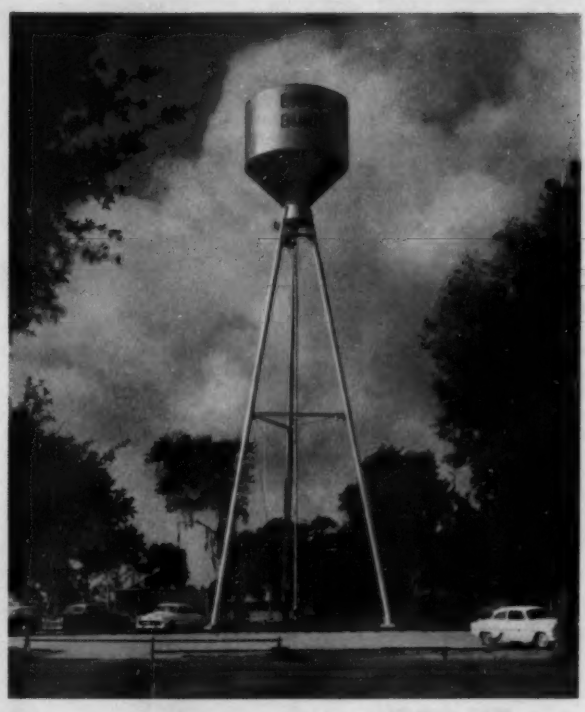

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(*Continued from page 82 P&R*)

Industrial Use of Water. C.S.I.R. Research Rev. (S.Afr.), 7:44 ('57). Govt. of S.Afr. has introduced legislation to control poln. of rivers and lakes. Permit must be obtained from Minister of Water Affairs if industrial undertaking requires more than 50,000 gpd. Before permit is granted, availability of water in area concerned, nature and method of purif. of effluent, degree to which it will be purified and capac. of body of water into which it will be dischdg. are considered. Water Act also requires that industrial waste waters or sewage effluents shall conform with stds. prescribed by minister, and shall then be returned to stream from which water was originally taken.—*WPA*

Process Waters of the Chemical Wood-Working Industries. H. Totterman. Paperi ja Puu (Fin.), 38:466 ('56). Anal. data of Fin. river and lake waters are given together with data of consumption of process water in various branches of woodworking industry and recommended compn. of process water in chem. pulp and rayon production. Data are given in tables. Different stages of pulping processes require water of different deg. of purity. Process water can be reused as water of circulation. Soft surface waters of Fin. are largely suitable for pulp and paper mfr., but they contain substances such as humus, iron, and manganese which could cause trouble in higher concns. —*WPA*

Preparation of Industrial Waters and Treatment of Effluents. R. Colas. Assoc. Tech. Ind. Papetiere (Paris), 5:199 ('57). Summary of methods (demineralization with exchange resins, electrodialysis membranes, hexametaphosphate, and removal of org. matter by flocculation, decantation, and filtration) for treatment and purif. of industrial waters is given together with some particular aspects of water utilization in Fr.—*CA*

(*Continued on page 86 P&R*)

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(Continued from page 84 P&R)

Water Use in Industry. R. L. DERBY. Proc. ASCE, **83**:IR2, Paper No. 1364 ('57). Author discusses use of water in industry, with particular reference to quant. and qual. of water required for specific industries. Reduction in fresh-water requirements by reuse of water, use of sewage works effluent, and use of sea water or brackish water where possible, is considered.—*WPA*

Water and Waste Waters in the Fermentation Industry. I. B. NIETSCH. Mitt. Versuchsstation Garungsgewerbe in Wien (Vienna), **12**:192 ('55). First part of article on water and waste water problems of fermentation industries deals with water supplies. High water demand of breweries and other fermentation industries makes it generally more economical to use private supplies which, in Aust., are practically always drawn from ground water. Author deals with causes and prevention of aggressive action on metals and concrete, meaning and importance of equil. in water, of reduced water, effects of iron and manganese and methods for their removal, and methods for disinfection of water.—*WPA*

Water Supplies of Industry in the Appendix to the Industrial Report 1955. Gas- u. Wasserfach (Ger.), **98**:443 ('57). Figures are given for amt. of water used in industries of Ger. states during yr '55. Total amt., of 5.96 billion cu m, shows increase of about 35% over figures for '51. Of this total, 30% is drawn from ground water and springs, 55% from surface water, 14% from outside sources—mainly public supplies—and small remainder from rain water.—*WPA*

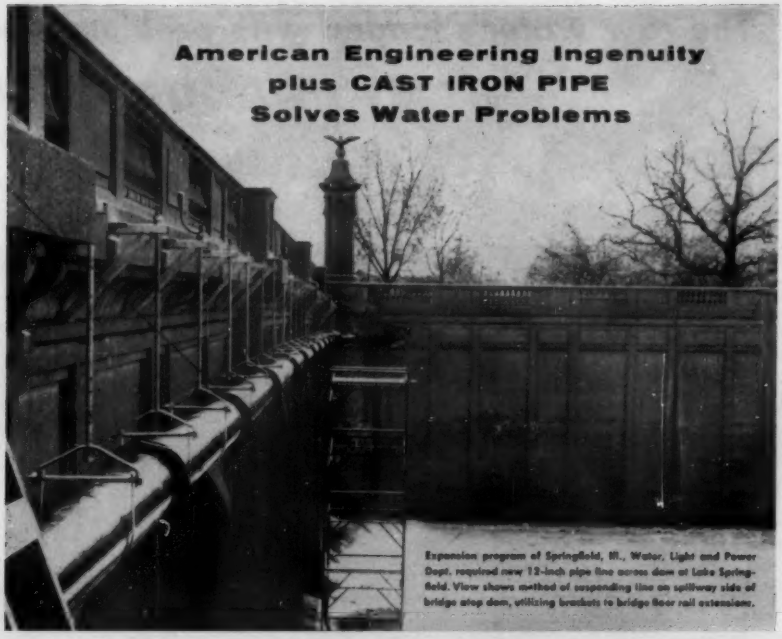
The Treatment of Water Supplies for Dairies by Means of Condensed Phosphates. R. FAIVRE. Tech. Eau (Brussels), **9**:107:29 ('55). Author discusses chemistry of polyphosphates in relation to their use in treatment of water supplies for dairies, for prevention of corrosion and scale formation in equip. and as cleansing agents in conjunction with detergents.—*WPA*

Industrial Water Supply From the Example of a Foundry. A. KOHLER. Neue Deliwa Z. Forder. Gas-, Wasser u Elektrizitatsfaches (Ger.), 375 ('56). Water supply system of foundry is described. As amt. of water required is large, recirculation systems are used in different parts of works according to requirements as to qual. of water. Chem. and bact. anals. are made of circulating water and, where necessary, it is disinfected by chlorination. Replacement arrangements and temp. control are described. —*WPA*

RADIOACTIVITY

The Public Health Implications of Radioactive Fallout in Water Supplies. H. A. THOMAS. Am. J. Public Health, **46**:1266 ('56). Tests were made on samples of rain and stream water, soil, and water from rapid sand filtration plants in eastern Mass. before and after nuclear weapons tests to ascertain amt. of radioactive fallout contamn. Author describes procedure for water anal. in lab. and lists no. of long-lived fission products which may be found in contamd. water sample, of which most common is strontium 90. Radiations of concern in fallout are gamma rays, and alpha and beta particles, which may cause internal radiation if water is used for drinking purposes. Internal radiation may cause death of cells, incapability of cells to divide, or structural changes to chromosomes or cytoplasm of cell. Clinical experience has indicated that safe level of absorption of radiation is 0.3 roentgens per wk. Math. model of uptake and radiation in human tissue is appended. Radioactive fallout has physical appearance similar to, and of same particle size as, dust which can be carried in air masses. After atomic explosions in Nev., streams in Mass. became contamd. from radioactive air mass. Graphs are given showing radioactivity measurements in Mass. surface waters after nuclear weapons tests, highest levels of radioactivity occurring 5–10 days after atomic explosion. Rate of disappearance of activity was also observed. About 1 mo. was required for stream to return to normal. In some cases, no increased radioactivity was noted in Mass. waters after explosion, indicating that air mass passed in another direction from Nev. Findings support view that amt. of radiation produced by nuclear weapons tests is not great enough to constitute health hazard or seriously affect inherited genetic constitution. —*WPA*

(Continued on page 90 P&R)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Expansion program of Springfield, Ill., Water, Light and Power Dept. required new 12-inch pipe line across dam at Lake Springfield. View shows method of suspending line on spillway side of bridge atop dam, utilizing brackets to bridge floor rail extensions.

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(*Continued from page 86 P&R*)

The Use of Radioisotopes in Hydrology. II. A Method for Determining the Abundance in Ground Water Streams. H. Moser; F. Neumaier; & W. Rauert. Atomkern Energie, 2:225 ('57). Principal problem of hydrological measurement of water closure consists in detn. of amt. of ground water streams in unretarded state. —*PHEA*

The Use of Radio-Isotopes for the Detection of Leaks. A. Wildblood. Steam Engr., 27:312:25 ('57). Procedure for use of radioactive isotopes for detecting leakage of liq. and gases is described, including methods for detecting leaks in water main.—*WPA*

The Importance of Radioactivity in Water Supply and Sewage Treatment. W. Stumm. Schweiz. Z. Hydrol. (Switz.), 17: 173 ('55). Author ests. that in Switz. in near future there will be acute problem as to threshold levels for radioactivity in drinking water. Damaging action of radioactive water is described and technical possibilities of its purif. are indicated. Water experts should develop purif. processes to remove radioactivity.—*WPA*

Sensitivity and Speed in the Evaporation Method of Measuring Radioactivity in Water Residues. P. Cohen; A. Reiffsteck; & G. Wormser. Energie Nucleaire (Fr.), 1:20 ('57). 2-hr procedure for detg. radioactivity in contamd. water based on Sr^{90} in equil. with Y^{90} is presented. Calibration curves, based on 8×10^{-8} μc/cc as min. detectable amt. of Sr^{90}, are constructed which relate evapn. time, counting time, and manipulation time with vol. of liq. Procedure based on these results utilizes 200 cc of liquid, which is evapd. below bp. with aid of current of hot air. Residue is dissolved in 1*N* HCl, transferred to watch glass, dried under infrared radiation, and counted. Correlation of exptl. results with theory avgd. 86%.—*CA*

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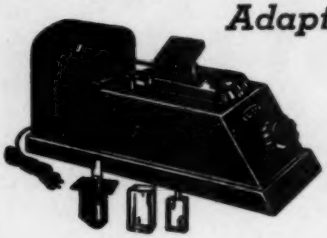

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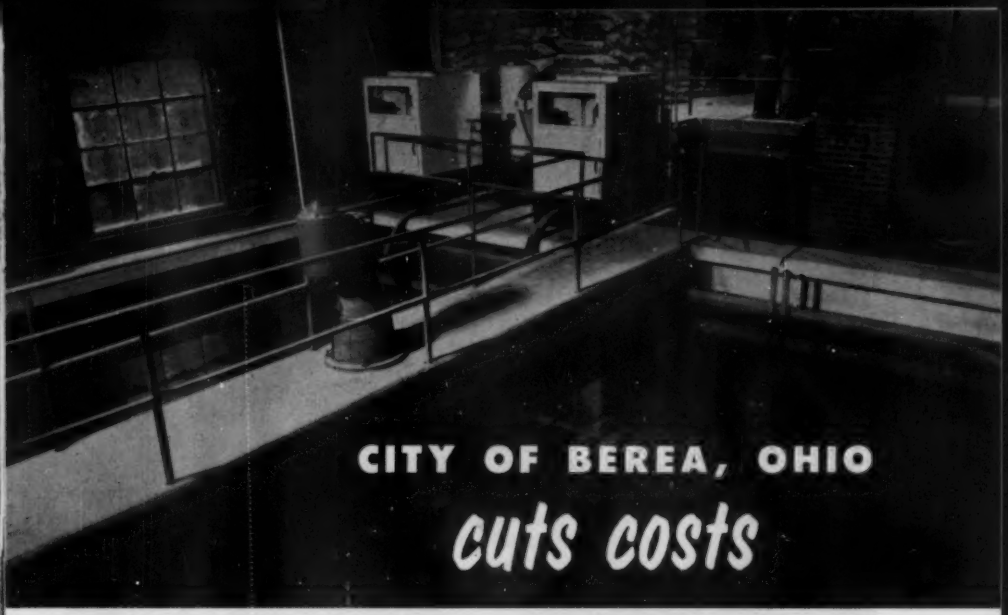

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Section Meetings

Arizona Section: The 1958 annual meeting of the Arizona Section was held jointly with the Arizona Sewage & Water Works Assn. on May 15–17 at the El Conquistador Hotel, Tucson. More than 300 attended. [A list of the technical papers presented will appear in the December 1958 JOURNAL.]

Officers elected for the coming year were: chairman—A. L. Frick Jr.; vice-chairman—Harry Bigglestone; secretary—Stanford I. Roth. Dario Travaini continues as director.

Past-Chairman Quentin Mees was the Fuller Award nominee for his services to the Section, as well as his leadership in the training and certification program. Safety Awards Committee Chairman R. E. Polenske presented Awards of Merit for 1956 safety records to Ajo Improvement Co., Monterey Water Co., and Mockingbird Water Co.; for 1957, Arizona Water Co. won both an Award of Honor and an Award of Progress, while Ajo Improvement Co. again received an Award of Merit.

The meeting terminated with a dinner dance Saturday evening, at which the new officers were presented. Both the technical program and the social activities at the meeting were considered outstanding.

STANFORD I. ROTH
Secretary-Treasurer

Southwest Section: The Southwest Section held its 47th annual meeting in Dallas, Tex., Apr. 20–25, 1958, meeting jointly with the parent Association for the first time. It is estimated that approximately 900 from the Southwest Section attended.

Delegates from the Southwest Section held a group luncheon in the Hotel Adolphus Monday, Apr. 21, at which AWWA officers were official guests. A highlight of the luncheon was an impromptu songfest performed by none other than Presidents Merryfield and Finch, Vice-President Grayson, Treasurer Orchard and Dallas host Henry Graeser.

The following awards were acknowledged or made: a Past President's Certi-

(Continued on page 96 P&R)

ARREST
RED WATER DUE TO IRON IN WATER AND IRON PICKUP IN THE MAINS.
STAINING OF PLUMBING FIXTURES IN CUSTOMER RESIDENCES.
EXCESSIVE MAINTENANCE ON WATER METERS, PIPES AND VALVES DUE TO BUILD UP OF DEPOSITS IN THE WATER SYSTEM, WITH
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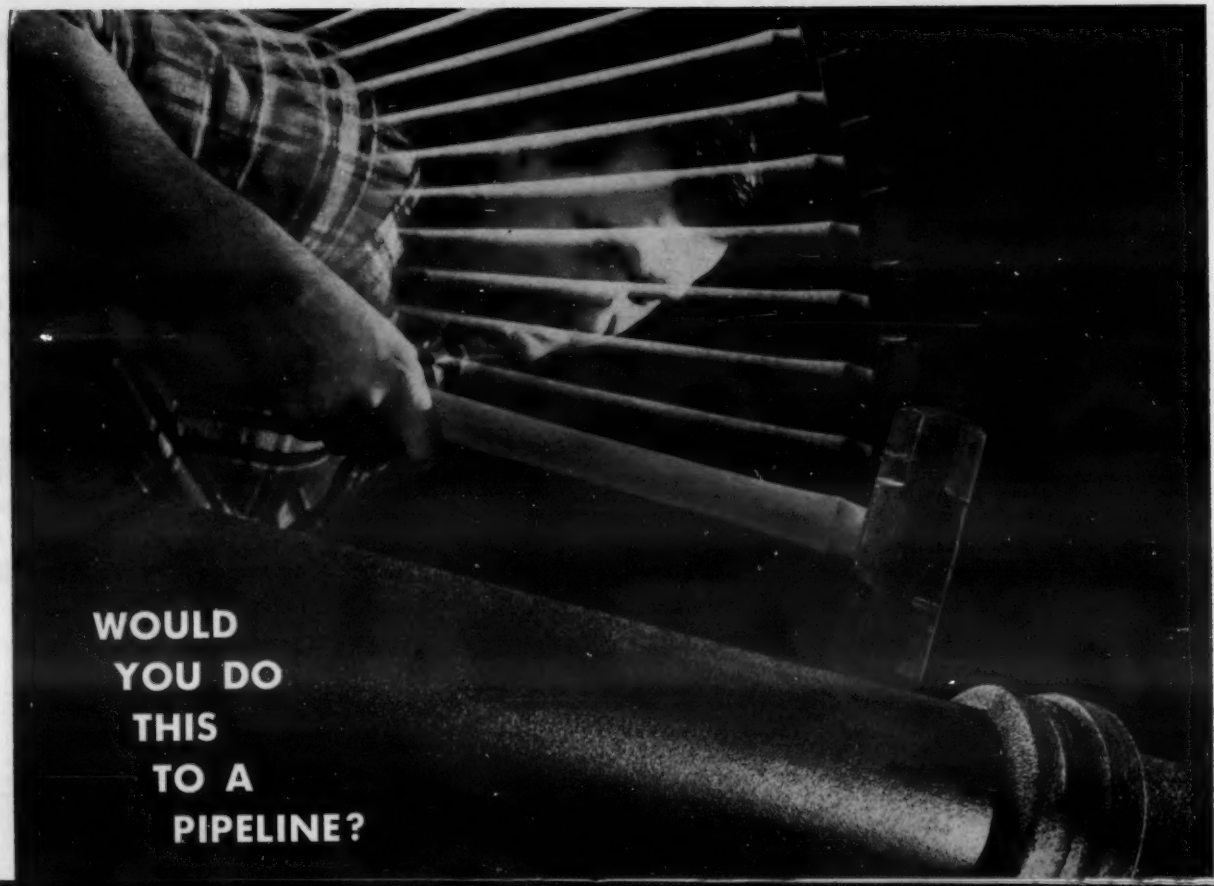
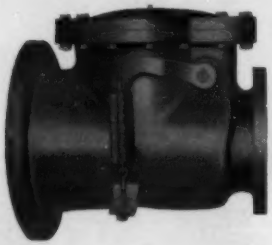


CHECK VALVE SLAMMING CAN BE JUST AS BAD!

CHECK VALVE SLAMMING CAN BE JUST AS BAD!



Even moderate slamming can raise cain with a pump discharge line, causing leakage, throwing pipes out of line or causing other damage that may not be discovered for years. And heavy slamming can cause serious damage and service interruption.

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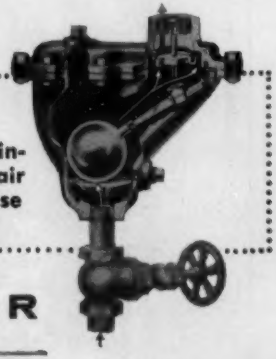

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VALVES & HYDRANTS

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Section Meetings

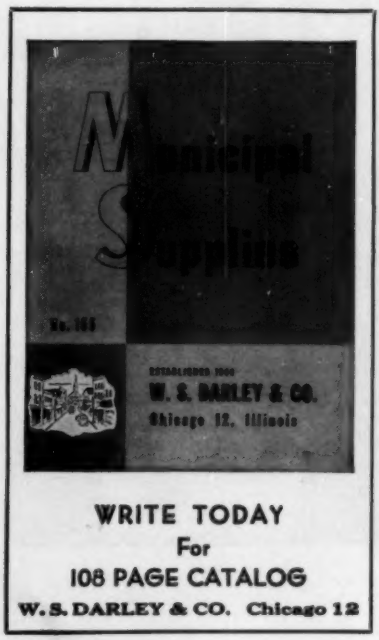
(Continued from page 92 P&R)

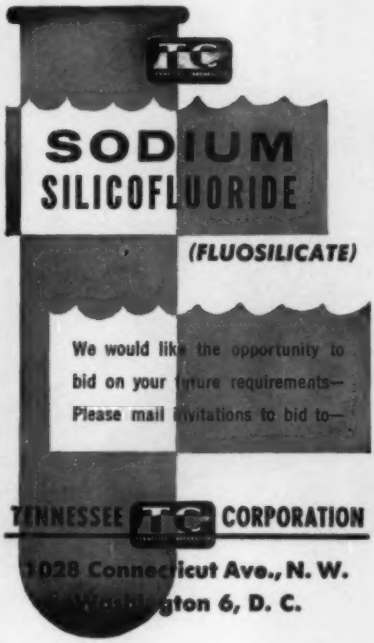
ficate was given to Haskell Street by Director Hoefle; President Merryfield presented Life Membership Certificates to Vic Ehlers and O. M. Smith; President Finch announced Honorary Memberships for Morrison Cunningham and Vic Ehlers; J. R. Pierce, former director, announced that Charles Williams and Johnny Jackson had received Egmont S. Smith Memorial Scholarship Fund Awards; Treasurer Orchard announced that Fred Puckhaber was the recipient of the George Warren Fuller Award.

The following officers were elected to begin their term of office Oct. 16, 1958: chairman—Robert L. Lawrence Jr., Alexandria, La.; vice-chairman—Henry J. Graeser Jr., Dallas; Arkansas trustee—Solon S. Sanderson, Marianna; Louisiana trustee—A. A. Hirsch, Shreveport; Oklahoma trustee—Clarence R. Holden, Tulsa; Texas Trustee—Victor R. Schmidt Jr., Austin.

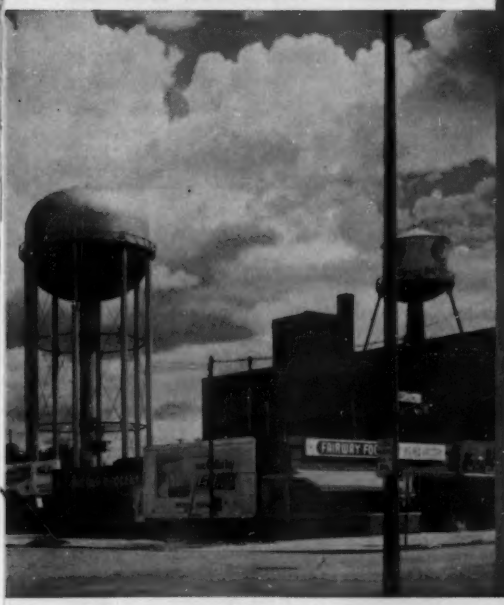
The present officers and officers-elect held a board meeting and took the following action: L. A. Jackson was reelected secretary for a 1-year term. J. R. Pierce was reelected for 3-year terms to both the Publication Committee and the board of trustees of the Southwest Section Memorial Scholarship Fund. The board unanimously approved a change in the name of the Egmont S. Smith Memorial Scholarship Fund to "Southwest Section Memorial Scholarship Fund."

L. A. JACKSON
Secretary-Treasurer





Part of the skyline at FARGO, NORTH DAKOTA



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The Reading Meter

Bergey's Manual of Determinative Bacteriology. *Robert S. Breed, E. G. D. Murray & Nathan R. Smith. Williams & Wilkins Co., Mount Royal & Guilford Aves., Baltimore 2, Md. (7th ed., 1957) $15*

The most obvious change from the sixth edition is the slimmed-down appearance of No. 7, resulting from the removal of some of the material previously included. Nearly all species that were regarded as inadequately described or that could not be definitely placed have been excluded, together with many of the less important synonyms of accepted species, the index to the literature, the host and habitat index, and information of merely historical interest. The result is that the manual contains more adequate descriptions of more organisms than former editions and yet is of more convenient size. Much of the material eliminated will appear in a companion volume to be known as the *Index Bergeyana* and will thus be available to those requiring it. A number of other internal revisions have been made in the manual, and a useful key to species determination has been added. The new edition can be said to represent a substantial improvement over what was already the outstanding reference work in its field.

Zinsser: Bacteriology. *David T. Smith & Norman F. Conant, ed. Appleton-Century-Crofts, Inc., 35 W. 32nd St., New York 1, N. Y. (11th ed., 1957) 953 pp.; $12*

During the 5 years since the previous edition of this standard text appeared (1952), the number of significant publications in the field of microbiology was more than double that of the preceding 5 years. Consequently, every chapter in the eleventh edition has been either extensively revised or completely rewritten. The sections on bacterial physiology, immunology, and the viruses have been entirely rewritten and enlarged, and a new chapter has been added on the blood groups and immunohematology. Also included in the eleventh edition is information on the susceptibility of each microorganism to the newer antibiotics.

Register of Dams in the United States. *T. W. Mermel, ed. Sponsored by US Committee of the International Commission on Large Dams. McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N.Y. (1958) 444 pp.; $12.50*

This ready reference manual provides the essential statistics on over 2,800 important dams in the United States. For each dam, it gives the name, location, structural data, reservoir capacity, ownership, by whom the engineering was performed, and who were the construction contractors. Providing uniform reference to and comparison of statistics on dams, it enables one to visualize both the magnitude of any structure and the importance of its engineering accomplishments. For quick, convenient reference, the dams are alphabetically listed by name and a cross reference of reservoir names (which may be different from those of the dams) is provided. Pictures of over 300 dams are included. In addition, the book presents a summary of laws of all 48 states

(Continued on page 100 P&R)

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. . . that conform to A.W.W.A. specifications in all respects

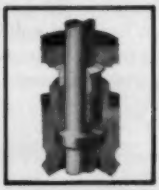
FIG. 56
- Inside Screw
- Non-Rising Stem
- Parallel Seats
- Bell Ends

FIG. 571X
- Inside Screw
- Non-Rising Stem
- Parallel Seats
- Mechanical Joint Ends

FIG. 561
- Inside Screw
- Non-Rising Stem
- Parallel Seats
- Flanged Ends

FIG. 556
- Outside-Screw-and-Yoke
- Rising Stem
- Parallel Seats
- Flanged Ends

Construction features . . .



Conventional stuffing box
with adjustable gland has ample space for packing that conforms to Federal specification HH-P-106c. The bottom face of the stuffing box flange is faced smooth to form bearing surface for stem thrust collar.

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once installed no adjustment of any kind is required. The top O-Ring is the dirt seal and the bottom O-Ring is the pressure seal.

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The Reading Meter

(Continued from page 98 P&R)

dealing with the supervision and control of dams. Engineers or owners considering dam construction in any state will find concise information on what type of control is exercised by the state, as well as the name and address of the appropriate official and agency which exercises such control.

Engineering Inspection, Measurement, and Testing. *H. C. Town & R. Colebourne. Philosophical Library, 15 E. 40th St., New York 16, N.Y. (1956) 192 pp.; $8.75*

This useful, well illustrated volume covers such topics as the function of the inspection department, principles of precision measurement, comparators and measuring machines, workshop inspection methods, and screw thread measurement. By no means comprehensive, the book is intended for students in technical colleges, but it should prove of practical interest to engineers engaged in precision measurement and inspection.

Best's Safety Maintenance Directory, 1958–59. *Alfred M. Best Co., 75 Fulton St., New York 38, N.Y. (7th ed., 1958) 642 pp.; $7.50 ($4, plus postage, to AWWA members so identifying themselves—order direct from publisher, attention S. A. McAshan)*

Prepared with the help of nationally known safety experts, this unique directory describes more than 2,600 products, devices, and equipment, and lists the names and addresses of 2,500 manufacturers. Some of the fields covered are personal protection equipment, materials handling, plant maintenance and sanitation, machinery guarding and control, laboratory safety, and aboveground protection. Concise descriptions of the structure and purpose of the various devices, often with photographs, are followed by lists of manufacturers and distributors of the products. Indexes for ready refer-

(Continued on page 102 P&R)

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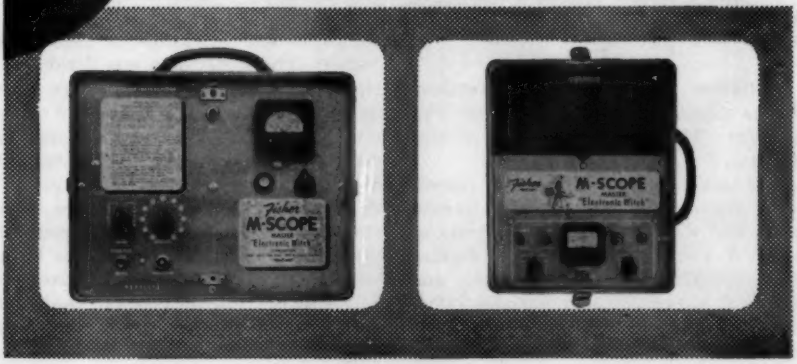

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(Continued from page 100 P&R)

ence are included, and the attractive format makes the book easy and pleasant to use.

Statistics on Outdoor Recreation. *Marion Clawson. Resources for the Future, Inc., 1145—19th St., N.W., Washington 6, D.C. (1958) 165 pp.; $2*

This statistical study of outdoor recreational facilities covers national forests, parks, and wildlife refuges; reservoirs of the TVA, Corps of Engineers, and Bureau of Reclamation; and state, county, and municipal parks. It also includes information on the number of resident and nonresident hunting and fishing licenses issued by the states.

The data presented in the 94 pages of tables are necessarily indicative rather than comprehensive or absolute. They do present an interesting picture of public outdoor recreation which may be reasonably correct, particularly as regards the long-term trend. Accordingly, this study has much value for public officials.

Foundations: Design and Practice. *Elwyn E. Seelye. John Wiley & Sons, Inc., 440—4th Ave., New York 16, N.Y. (1956); $16*

In one convenient volume this book provides up-to-date information on all phases of foundation work. The author begins with elementary design and then goes on to more complex problems. Broad in scope, the book covers such topics as waterproofing, underpinning, economics of design, dam foundations, applied soil mechanics, pipe and culvert foundations, and embankments. Tables of design data are included.

Cavitation in Hydromechanics. *Philosophical Library, 15 E. 40th St., New York 16, N.Y. (1957); $15*

This book contains the 22 papers presented at the Symposium on Cavitation held at the National Physical Lab., Teddington, England, in September 1955. First issued as the *Proceedings of the Symposium* in 1956 by Her Majesty's Stationery Office in London, it has been republished by the Philosophical Library in New York to be generally available to engineers and scientists in the United States. The symposium was divided into six sections, each with from three to six papers dealing with some aspect of cavitation. "Factors Governing Cavitation Inception" was the subject of the first technical session, with consideration given to the presence of air or gases and tensile stresses in flowing water. "Experimental Techniques" were discussed in the second session, with a description of water tunnels and the instrumentation needed for measuring cavitation. "Scale Effect Factors" were treated extensively, and the influence of external actions was evaluated. "Effects on Hydrodynamic Performance" brought out the change in flow characteristics, particularly with respect to hydrofoils and the influence the profile had upon cavitation. "Cavitation Damage" was treated at length, with measuring and testing procedures described in detail. Ultrasonic cavitation was also discussed. A valuable section of the book is the discussion of the various papers, which follows each section of the symposium. The book will be of interest to research workers and others concerned with the technical aspects of cavitation. To the layman, it may not have great appeal but it can be of value as a reference work to show the state of the art in 1955.

Uniform System of Accounts for Water Utilities, 1957. *National Assn. of Railroad & Utilities Commissioners, Box 684, Washington 4, D.C. (1958); paperbound; Class A & B, 128 pp., $4.50; Class C, 100 pp., $3.50; Class D, 64 pp., $2*

After several years of discussion, a revision of the 1939 accounting system was approved by NARUC in 1957 and is now available in three paperbound volumes—one for Class A and B utilities, covering those with annual water operating revenues of $250,000 or more; another for Class C utilities, with revenues of $50,000–$250,000; and a third for Class D utilities, with less than $50,000 revenue.

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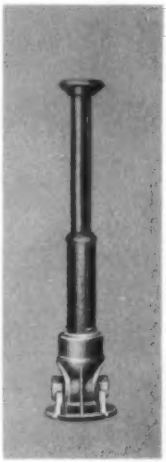

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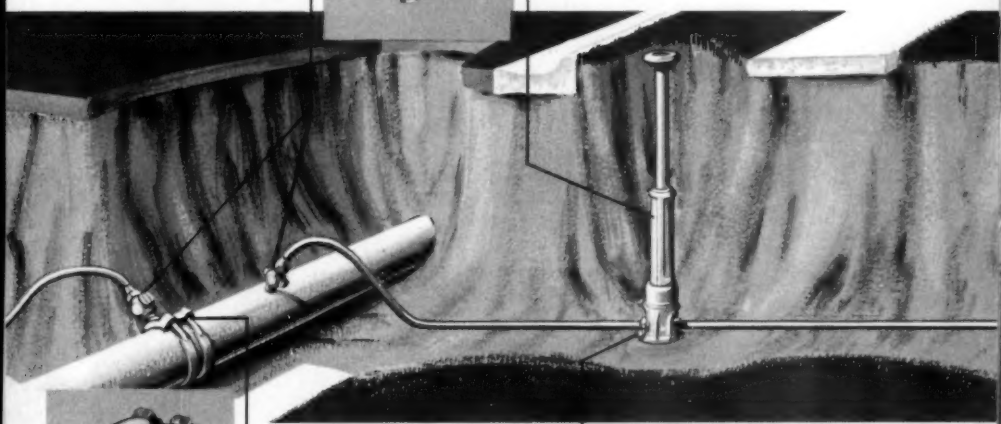

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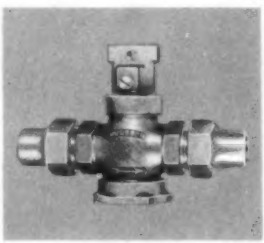

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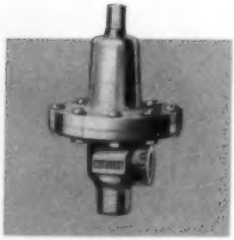

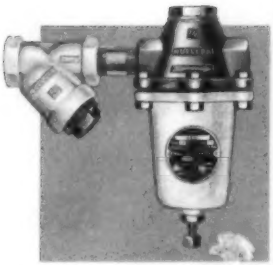

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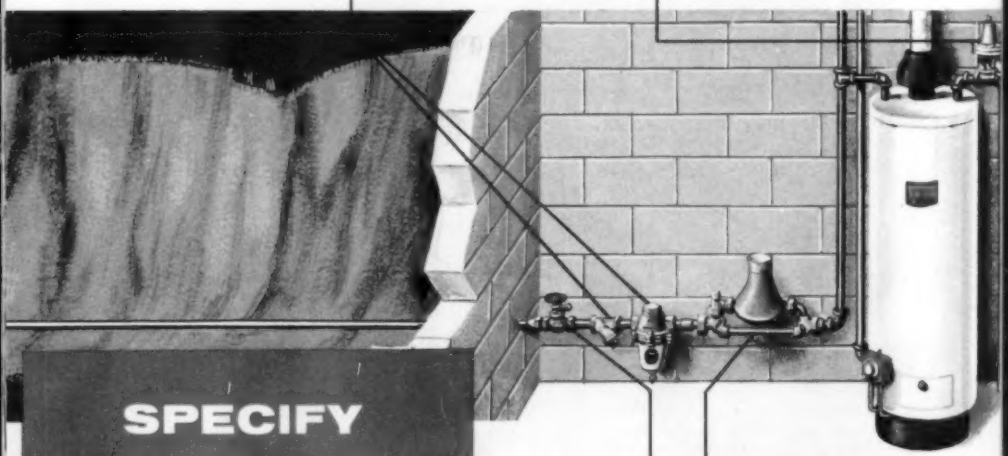

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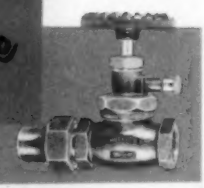

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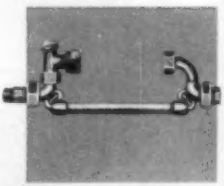

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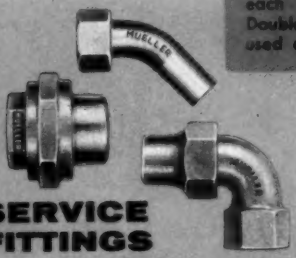

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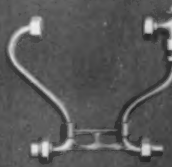

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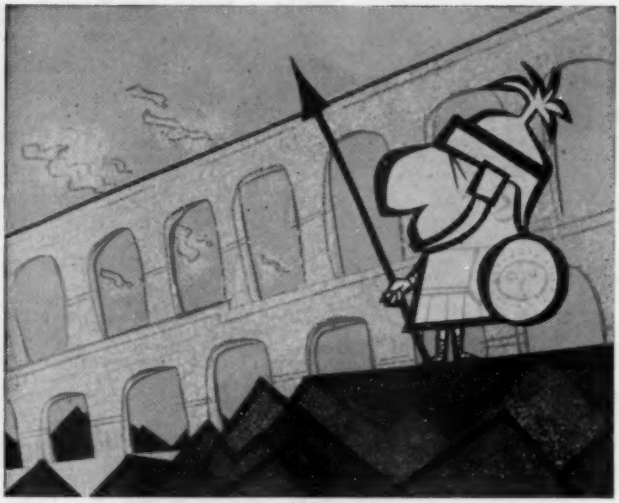

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Alsup, Lawrence E., Engr., Templeton & Linke, 500 Dooly Bldg., Salt Lake City 1, Utah (Jul. '58)

Alvarez, Jaime E., Designer, San. Eng. Dept., Rader & Assocs., 111 N.E. 2nd Ave., Miami, Fla. (Apr. '58)

Antwerp Board of Public Affairs, Richard Doster Rhoad, Supt., Water Dept., Antwerp, Ohio (Corp. M. Jul. '58)

Barnes, Mark H., Sales Engr., Hersey Mfg. Co., 1450 Chapin Ave., Burlingame, Calif. (Jul. '58)

Beaver Dam Water Works, John R. Birch, City Engr., City Hall, Beaver Dam, Wis. (Corp. M. Apr. '58)

Birch, John R.; *see* Beaver Dam (Wis.) Water Works

Bower, Clark D., Vice-Pres., Layne & Bowler Pump Co., Box 6991, Los Angeles 22, Calif. (Apr. '58)

Breiby, Norman H., Mech. Supt., Oscar Mayer & Co., 910 Mayer Ave., Madison 4, Wis. (Apr. '58)

Brice, D. B., Sr. Research Engr., The Fluor Corp., Ltd., 12000 Washington Blvd., Whittier, Calif. (Jul. '58)

Brookfield, Village of, C. Harold Eash, Village Mgr., 8820 Brookfield Ave., Brookfield, Ill. (Corp. M. Jul. '58)

Brooks, Donald C., Asst. Engr., Design Div., Metropolitan Water Dist. of Southern Calif., 306 W. 3rd St., Los Angeles 13, Calif. (Apr. '58)

Bryan, Edward, San. Engr., Dow Chem. Co., Midland, Mich. (Jan. '58)

Callender, W. S., Sales Mgr., Seattle Concrete Pipe Co., 7401—8th Ave., S., Seattle 8, Wash. (Jul. '53)

Campbell, Ronald J., 112 Boylan Lane, Blue Point, N.Y. (Apr. '54)

Clark, Joseph P., Water Chemist, South Dist. Filtration Plant, 3300 E. Cheltenham Pl., Chicago 49, Ill. (Apr. '58)

Cook, Donald F., Mgr., Glen Cove Plant, N.Y. Water Service Corp., 60 Glen St., Glen Cove, N.Y. (Apr. '58)

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Davis, C. Kay, Vice Pres., Pine Island Utilities Corp., Box 8643, Fort Lauderdale, Fla. (Jul. '58)

Duffy, Michael Patrick, Distr. Engr., Govt. Water Com., Cavaliers, Cross Rd. P.O., Kingston, Jamaica (Apr. '58)

Dunn, Luther Franklin; *see* Las Flores Water Co.

Eash, C. Harold; *see* Brookfield (Ill.)

Edens, William Ellsworth, Director of Public Works, Reidsville, N.C. (Apr. '58)

Evangelista, John A., San. Engr., Parsons, Brinckherhoff, Hall & Macdonald, 1917—73 St., Brooklyn 4, N.Y. (Jul. '58)

Fargo Water Dept., Fred C. Hagen, Comr., City Hall, Fargo, N.D. (Munic. Sv. Sub. Apr. '58)

Fee, Rufus S., Public Relations Repr., Metropolitan Water Dist. of Southern Calif., 306 W. 3rd St., Los Angeles 13, Calif. (Jul. '58)

Foster, James N.; *see* Mallinckrodt Chem. Works

Franklyn, Derer A., Mech. Engr., Sealand Products, Ltd., 2746 W. Broadway, Vancouver, B.C. (Jul. '58)

Frazier, R. W., Gen. Mgr., Water Dept., City Hall, Oshkosh, Wis. (Apr. '58)

Freeman, Charles W., Salesman, Mueller Co., Decatur, Ill. (Apr. '58)

Friesen, Pete F., Supt., Water Dept., 109 E. Birch, Dallas, Ore. (Apr. '58)

Gelin, Carl H., Vice-Pres., Layne Pumps, Inc., 4607 Ave. H, Lubbock, Tex. (Jul. '58)

Goetz, Frank L., Application Engr., McIntosh Equipment Corp., 15 Park Row, New York 38, N.Y. (Apr. '58)

Gordon Herkenhoff & Assoc., Walter Arthur Webster, Civ. Engr., Water Works Sec., 302—8th St., N.W., Albuquerque, N.M., (Corp. M. Jul. '58)

Greene, John, Operator & Works Mgr., E. Kingsport Utility Dist., Indian Springs, Tenn. (Apr. '58)

Griffith, Evan L., Assoc. Civ. Engr., Metropolitan Water Dist. of Southern Calif., 306 W. 3rd, Los Angeles, Calif. (Jul. '58)

Grigoropoulos, Sotirios Gregoire, Student in Chem. Eng., Sever Inst. of Technology, Washington Univ., Saint Louis 5, Mo. (Jr. M. Jul. '58)

Hagen, Fred C.; *see* Fargo (N.D.) Water Dept.

Hagestad, Herman T., Cons. Engr., 201 First National Bank Bldg., River Falls, Wis. (Apr. '58)

Hatfield, Howard L., Field Engr., Sparling Meter Co., Inc., 1690 Milwaukee St., Denver 6, Colo. (Apr. '58)

Hayes, Thomas A., Western Div. Mgr., Philadelphia Gear Works, 507 E. Olive, Gardena, Calif. (Apr. '58)

Hiestand, Jacob R., Owner, J. R. Hiestand, 71–73 S. 20th St., Battle Creek, Mich. (Jul. '58)

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Italiano, Johnny, Supt., Water Works, 1213 N. Center St., Beaver Dam, Wis. (Apr. '58)

Katzban, John M., Village Mgr., 801 E. Lexington Blvd., Whitefish Bay, Milwaukee 17, Wis. (Jul. '58)

Keeler, Ide Eldon, Public Health Sanitarian, San Bernardino County Health Dept., 316 Mountain View, San Bernardino, Calif. (Apr. '58)

Kywe, Aung, Exec. Engr., North Public Health Div., National Housing Board, Mandalay, Burma (Apr. '58)

Lamb, James C., III, 836 Thomas Ave., Bound Brook, N.J. (Apr. '58)

Las Flores Water Co., Luther Franklin Dunn, Supt., 428 Sacramento St., Altadena, Calif. (Corp. M. Jul. '58)

Leclerc, Andre, Assoc. Prof.-Head, Div. of San. Eng., Ecole Polytechnique de Montreal, 2500 Guyard, Montreal, Que. (Apr. '58)

LeVan, Keene L., Vice-Pres., Pride Eng., Assocs., 161 Collins Ave., Penn Hills, Pittsburgh 35, Pa. (Jul. '58)

Lindo, George William, Sr. Exec. Engr., Water Supplies Div., Ministry of Home Affairs, Kingston, Jamaica (Apr. '58)

Lonner, Harry W., Chief Civ. Eng., Quinton Engrs. Ltd., 812 W. 8th St., Los Angeles 17, Calif. (Jul. '58)

Loves Park Water Dept., Ellsworth L. Rufty, Supt., 5440 Walker Ave., Loves Park, Ill. (Corp. M. Jul. '58)

Mallinckrodt Chem. Works, James N. Foster, Mgr., Indus. Eng. Dept., Uranium Div., Box 472, St. Charles, Mo. (Corp. M. Jul. '58)

Martin, A. S., Prin. Eng., Gee & Jenson, Cons. Engrs. Inc., 117½ S. Dixie, West Palm Beach, Fla. (Apr. '58)

McDonald, Charles C., Chief, Gen. Hydrology Branch, US Geological Survey, Washington 25, D.C. (Jul. '58)

McDonnell, Joseph B., San. Engr., San. Eng. Dept., Chas. W. Cole & Son, 220 W. La Salle Ave., South Bend 1, Ind. (Jul. '58)

McReynolds, John W., Mgr. of Sales, Welland Tubes Ltd., 100 Church St., Toronto, Ont. (Jul. '58)

Meisels, Max, Assoc. Engr., Mech. Sec., Metropolitan Water Dist. of Southern Calif., 306 W. 3rd St., Los Angeles 13, Calif. (Jul. '58)

Mielke, Robert E., Asst. Supt., Water Dept., E. 914 Grace Ave., Spokane, Wash. (Jul. '58)

Miller, Frank E., Vice-Pres., Pressure Pipe Co. of Canada Ltd., 60 Vulcan St., Rexdale P.O., Toronto, Ont. (Jul. '58)

Miller, Grant E., Asst. Supt., Bureau of Water Works, 112 City Hall, Portland 4, Ore. (Jul. '58)

Mills, William Howard, Gen. Mgr., The William H. Mills Water Co., 1909 Granito Vista, Tucson, Ariz. (Jul. '58)

Moeller, Dade W., Chief, Radiological Health Training, Robert A. Taft San. Eng. Center, US Public Health Service, 4676 Columbia Pkwy., Cincinnati 26, Ohio (Jul. '58)

Morris, James M., Jr., Sr. Hydr. Engr., Dept. of Water Resources, 1120 N St., Sacramento 14, Calif. (Jul. '58)

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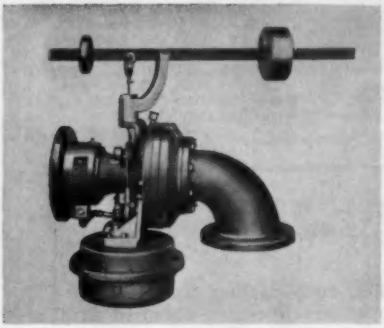

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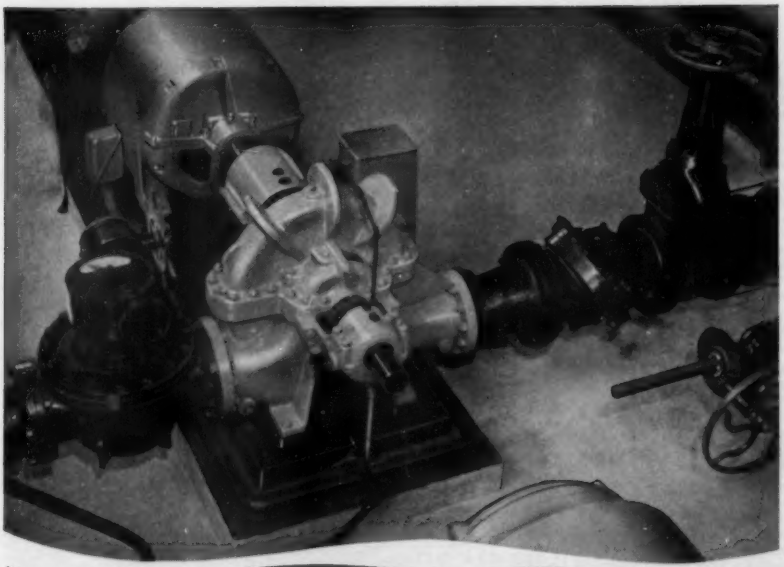

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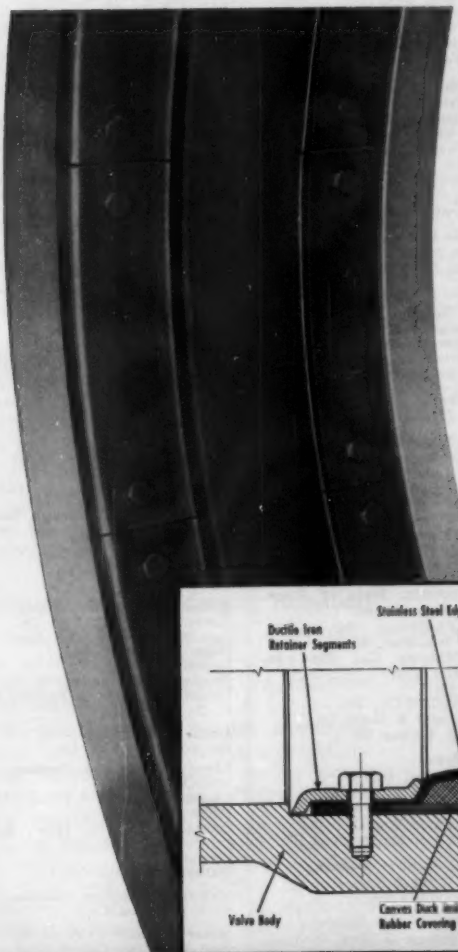

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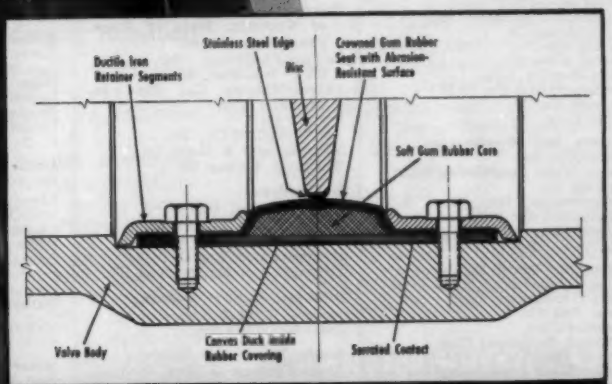

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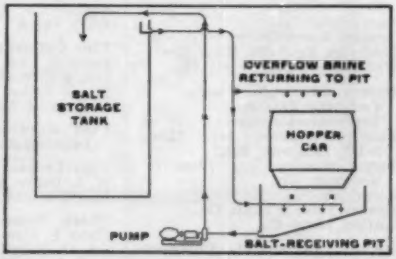
Planning to install water-softening equipment in your community?

Whether you're planning a soft water installation or have one already, you can save money with the correct techniques for storing, handling or using brine for regeneration. This is article #18 in a series prepared by International Salt Company.

Hydraulic Handling—Quick, Economical Way to Move Salt into Storage

Here's a new, effective method for moving salt from delivery cars or trucks into plant storage. Hydraulic Handling systems, already in operation in industry, have eliminated the expense of mechanical unloading equipment, and cut down considerably on man-hours needed to do the job.



Rock salt in hopper car is flushed into salt-receiving pit by brine returning from storage tank. Slurry of salt and brine is pumped continuously into the tank.

What is Hydraulic Handling? Very simply, Hydraulic Handling is the movement of granular salt in circulating saturated brine, through pipes. Referring to the diagram, you will note that dry salt from the hopper car is mixed with saturated brine in a salt-receiving pit. This slurry is pumped through a pipe to a salt-storage tank. Overflow brine from the tank continuously returns to the slurrying pit to carry more salt into storage.

Advantages of Hydraulic Handling

1. **Great flexibility.** Because *pipes* carry salt, a Hydraulic Handling system can be installed where it won't interfere with other plant activities.

2. **No need to move existing equipment.** Water treatment equipment that might obstruct mechanical handling devices simply doesn't get in the way of a Hydraulic Handling installation.

3. **Long life, low maintenance.** You need no safety guards . . . no roofing to protect salt from weather . . . no belt conveyors, elevators, or similar pieces of mechanical handling equipment. Also, there is never any salt dust that might corrode vital plant equipment.

4. **Unlimited capacity.** Hydraulic Handling systems can be designed to unload, move, and store any amount and type of salt—rock or evaporated. Whatever your specific needs, Hydraulic Handling can satisfy them.

You can get more information from International Salt Company on how Hydraulic Handling can work in your installation to cut down salt-unloading and salt-handling expense. One of our experienced sales engineers will be glad to work with you to determine the best system of Hydraulic Handling for your specific needs. Ask him . . . send a card or letter to International Salt Company, Inc., Scranton 2, Pa. . . . or contact our nearest district office:

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Sodium Hypochlorite:
John Wiley Jones Co.
Wallace & Tiernan Inc.

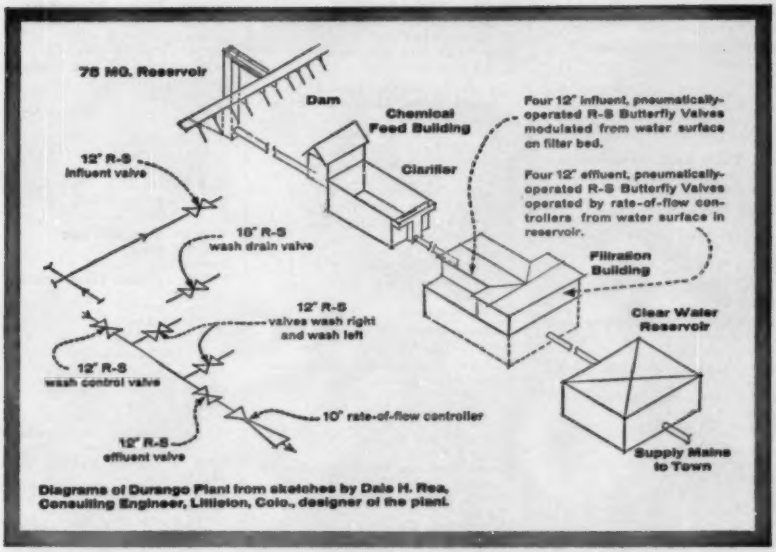
Sodium Silicate:
Philadelphia Quartz Co.

Sodium Silicofluoride:
American Agricultural Chemical Co.
Tennessee Corp.

Softeners:
Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon Co.
General Filter Co.
Industrial Chemicals, Inc.
International Salt Co., Inc.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.


75 MG. Reservoir
Dam
Chemical Feed Building
Clarifier
Four 12" influent, pneumatically-operated R-S Butterfly Valves modulated from water surface on filter bed.
Four 12" effluent, pneumatically-operated R-S Butterfly Valves operated by rate-of-flow controllers from water surface in reservoir.
12" R-S influent valve
18" R-S wash drain valve
Filtration Building
12" R-S valves wash right and wash left
Clear Water Reservoir
12" R-S wash control valve
10" rate-of-flow controller
12" R-S effluent valve
Supply Mains to Town
Diagrams of Durango Plant from sketches by Dale H. Rea, Consulting Engineer, Littleton, Colo., designer of the plant.

R-S Butterfly Valves used
exclusively at Durango, Colorado,

TO GIVE CLOSE FLOW CONTROL

Durango, Colorado's 8.7 mgd water treatment plant operates automatically. But accurate flow control is necessary in this gravity system if the proper rate of flow in the treatment process is to be maintained. R-S Rubber-Seated Butterfly Valves were chosen to do this job. Their angle seating provides more desirable control characteristics. It means *more precise regulation over a greater range* than is available with 90° seated valves. 25 R-S Rubber-Seated Butterfly Valves, ranging from 12" to 18" in size, are installed here.

To obtain full information on the full SMS line – Butterfly Valves, Rotovalves and Ball Valves – contact our nearest representative or write S. Morgan Smith Co., York, Penna.

S. MORGAN SMITH HYDRODYNAMICS

AFFILIATE: S. MORGAN SMITH, CANADA, LIMITED, TORONTO

Rotovalves • Ball Valves • R-S Butterfly Valves • Free-Discharge Valves • Liquid Heaters • Pumps • Hydraulic Turbines & Accessories

Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Alco Products, Inc.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Hays Mfg. Co.
Mueller Co.

Storage Tanks: see Tanks

Strainers, Suction:
James B. Clow & Sons
R. D. Wood Co.

Surface Wash Equipment:
Permutit Co.

Swimming Pool Sterilization:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Omega Machine Co. (Div., B-I-F Industries, Inc.)
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Inc.

Tanks, Steel:
Alco Products, Inc.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Tapping-Drilling Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.

Taste and Odor Removal:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
General Filter Co.
Graver Water Conditioning Co.
Industrial Chemical Sales Div.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Turbines, Water:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.

Valves, Altitude:
Golden-Anderson Valve Specialty Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.
S. Morgan Smith Co.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Corp.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Large Diameter:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Regulating:
DeZurik Corp.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co.
S. Morgan Smith Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

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Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Simplex Valve & Meter Co.

Waterproofing:
Barrett Div.
Inertol Co., Inc.
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Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
LaMotte Chem. Products Co.
W. A. Taylor & Co.
Wallace & Tiernan Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite: see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1957 AWWA Directory.

"Wherever Water Flows STEEL PIPES IT BEST"

STEEL SMOOTHS THE WAY!

Ductility and adaptability of steel fabricated pipe pay off when the going gets rough

Sloping down mountainsides . . . hanging suspended above canyons . . . tunneling through mud, clay or quicksand. That's where steel fabricated pipe measures up best to the task!

In fact, no other material promises the installation flexibility of steel. Reason: no other material is so strong yet ductile.

Only steel pipe, for example, could be supported over swamps on widely spaced piers. Only steel pipe could be assembled and joined in extra long lengths — then so easily lowered into the trench. And only steel pipe has the damage resistance to be laid above the ground.

Because it is so easy to haul, handle and join, steel pipe cuts costs by speeding the job. Special fabrications are quickly achieved. And once it's installed, you can be sure of *minimum* maintenance because steel resists unusual stress and strain.

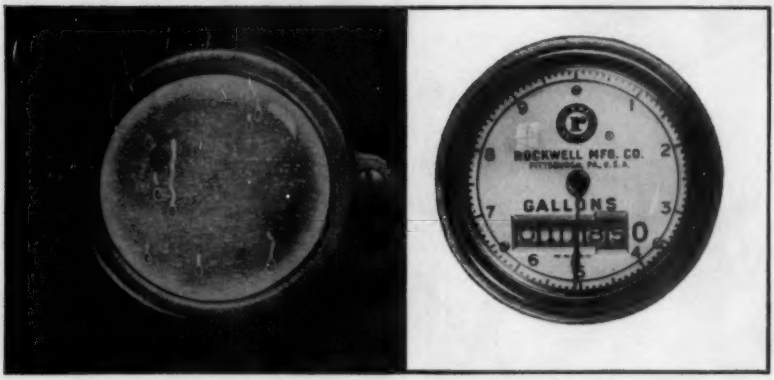
Steel fabricated pipe saves money. Specify it with confidence!

STEEL PLATE FABRICATORS ASSOCIATION

105 West Madison Street, Chicago 2, Ill.

STEEL PLATE FABRICATORS ASSOCIATION

What good is a meter if you can't read it?



DIRTY FACE

Condensation and dirt cloud the dial on this conventional register.

CLEAN FACE

Rockwell hermetically sealed register always presents a "clean face" to the meter reader.

YOU CAN ALWAYS READ A ROCKWELL SEALED REGISTER WATER METER

In recent years water utilities have spent thousands for oil enclosures, wipers and similar gadgets to lick the problem of fogged registers. Now, for not a penny extra, Rockwell offers a revolutionary new meter having a hermetically sealed register which completely eliminates condensation under the glass.

In the Rockwell Sealed Register meter all gearing, including the intermediate train, is encased in a sealed compartment high and dry above the measuring chamber. There's no stuffing box to leak or bind. A powerful magnetic coupling transmits motion smoothly and with the least possible friction. All this means less wear, less chance for corrosive attack, and, of course, easier maintenance at lower cost. Get full facts now, *write to Rockwell Manufacturing Company, Pittsburgh 8, Pa.*

SEALED REGISTER METERS

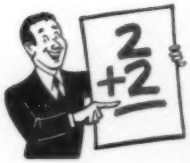
another fine product by

ROCKWELL

The solution to this problem is always the same . . . but

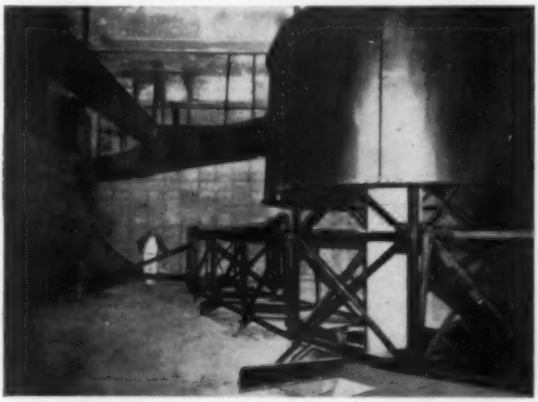
Water Treatment Problems are different

No two water treatment problems are exactly alike. The right solution to each can only be arrived at after a careful study of the local conditions. Variables such as raw water composition, rate of flow and results required automatically rule out the cure-all approach. The installation shown below is a good example of how equipment should be selected to fit the job . . . and not vice versa



St. Cloud, Minnesota

Dorr Squarex Clarifiers Installed Under City Park...



Underneath Hester Park are two of these large (55' sq.) Dorr Squarex Clarifiers.

In 1953, the City of St. Cloud, recognizing the obsolescence and inadequacy of their original water filtration plant, retained the services of Consoer, Townsend and Associates to design modern water treatment facilities to treat and soften Mississippi River water and which would be suitably attractive, as the plant was located adjacent to the city's Hester Park.

On October 31, 1957, the new St. Cloud Water Treatment Plant, situated on the Mississippi River, was officially opened. Over fifty percent of the plant's facilities are located under Hester Park; granite-faced administration and control buildings constitute the plant's exterior

Playing an important role in St. Cloud's new facilities are two Special SZ-7, Dorr Squarex Clarifiers, each 55 ft. sq. x 15 ft. s.w.d. These two Squarex Clarifiers, equipped with concrete center columns, are installed in underground clarifying basins, each of which will hold a half-million gallons. The Dorr Squarexes were designed for a population equivalent of 50,000 and average design flows of 9 MGD.

Squarex, T.M., Reg. U. S. Pat. Off.

DORR-OLIVER
INCORPORATED
WORLD-WIDE RESEARCH + ENGINEERING + EQUIPMENT
STAMFORD • CONNECTICUT • U. S. A.

St. Cloud's Administration & Control Building.

LEADITE

Trade Mark Registered U. S. Pat. Office

Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking